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Chemistry Activity Units for the Integrated Curriculum

C. Sidney Bjorlie

CHEMISTRY ACTIVITY UNITS FOR THE INTEGRATED CURRICULUM

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C. Sidney Bjorlie

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Erich Selke
Chairman

O. L. Kjerstad

E. D. Coon

J. V. Breitwieser
Director of Graduate Division

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CHAPTER 1

INTRODUCTION

In 1872 colleges began to set up standards for accepting chemistry as a college entrance requirement. This was the beginning of college influence or dominance over chemistry in our high schools. It had one good effect in that it led to laboratories being established in our high schools,and real laboratory procedure was begun. But this college domination had its ill effects also. Chief among them was the failure to popularize chemistry but rather to emphasize techniques of laboratory procedure and to make memorization of facts the chief aim. There was not much incentive for laboratory work either because the chief aim was the completion of a definite number of experiments rather than certain types, in order to qualify for college entrance.

But two factors have helped to change the point of view of the high-school chemistry teacher and to take away some of the college control. The World War, which brought emphasis on the discoveries of chemistry, and the demand of the common people to know more practical chemistry that is directed to the needs of human betterment have helped to bring about a change.

It is also the opinion of most educators that a high-school education should be more closely related to the common everyday needs and interests of the pupils. According to the Educational Policies Commission in its report, The Effect of Population Changes on American Education,[1] in 1936 about 65 per cent of the children fourteen to seventeen years of age were enrolled in our secondary schools, and only about 14 per cent of those of college age were enrolled in colleges. The question, therefore, is raised why we should teach our entire high-school group with the purpose in mind of preparing a small minority of them for college. This is true of the teaching of high-school chemistry as much as of any high-school subject. With the educational aims shifting to the vocational, a shift has occurred in the aims of science courses in high school toward the practical fact finding aspect. Emphasis is being placed upon making a living through the use of scientific knowledge rather than living a happier and more serviceable life. Efficient habits of thinking in terms of scientific materials has been pointed out as probably an important aim of teaching science in high school.

Statement of the Problem

In a recent analysis made by the National Survey of

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[1]Educational Policies Commission, The Effect of Population Changes on American Education, National Education Association of the United States and the American Association of School Administrators (June, 1938), p. 35.

Secondary Education[2] of thirty courses of study in chemistry, it was found that the practice was largely determined by the textbooks used and by the state courses of study. In a study of the outstanding textbooks used in North Dakota no book was found covering all the subject matter which, according to the opinions of experts, should be included.

The basis for what chemistry subject matter should be included in the integrated curriculum was obtained from three sources. A study was made of the National Survey of Secondary Education bulletin on Instruction in Science and also of the place of science in the integrated curriculum as discussed in Secondary Education, Principles and Practices, by Engelhardt and Overn. A thorough study was then made of the George S. Klovstad master thesis, The Chemistry Subject-Matter for Integrated Curriculums. This thesis contained the opinions of experts on what subject matter should be included in a course in high-school chemistry. After securing the opinions of experts on what subject matter should be included, the problem resolved itself into developing activity units covering this subject matter.

The teaching of chemistry under the unit plan as here presented has its problems. The first point that must be

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[2]Engelhardt and Overn, Secondary Education, Principles and Practices (D. Appleton Century Company, 1937), p. 393.

emphasized is that the course cannot be taught by the use of a basic text. The reason for this has been mentioned before. There are no chemistry texts at the present time containing all the subject matter presented here. A text will not be found presenting the subject matter in the time order used here. It will, therefore, be necessary to teach the subject by means of sufficient reference material for each unit. A skeleton outline with the reference material should be worked out by the instructor for each unit and given to each student before beginning the study of the unit.

The laboratory material to be covered for each unit has been suggested in some cases in the various units. Most of the additional laboratory work necessary to complete the work in each unit, may be found in the laboratory manuals now in common use in our high schools. The students should become proficient in handling laboratory equipment not as technicians but for the sake of acquiring practical skill.

The units are not intended to entirely limit the instructor in the choice of subject matter. They are merely intended to serve as a guide toward a better selection of subject matter, presented in logical time order.

The charts and diagrams found throughout the units are to be used as aids toward a clearer understanding of relative importance and in some cases for emphasis. The charts of the nitrogen and carbon dioxide cycles in Unit 2 must receive special attention as they should serve to unify the material in this entire unit.

The teaching of chemistry under this unit plan should not be attempted by an instructor who has not had a broad training in the field of science.

Statement of Method

The method of study used was first developing a skeleton outline of the subject matter to be included in the course. Then by examining the outstanding texts used in teaching chemistry in North Dakota, as well as new outstanding texts not yet adopted in this state, the detailed units were developed.

At the close of each unit, text book references were worked out.

Statement of Limitations

The subject matter as here presented has been used in teaching high-school chemistry by two instructors. A number of the students have attended college and have taken college chemistry. Comparisons have been made of the ability of these students to compete with those having taken the more technical course of high-school chemistry. In almost all cases the comparisons point to the fact that the students taking the practical course were just as able and in some cases more able to successfully continue college chemistry than the others. No way has been tried to find out of what more practical value this course has been, especially to those students who have not had the opportunity to attend college after completing high school, over the other more technical course.

The conclusions that may be drawn from this may be erroneous for two reasons:

(1) The results may be due to the efficiency of instruction as much as to the type of subject matter included in the course.

(2) The comparisons have been made of a relatively small number of students, and the course has only been tried out by two instructors. It will be necessary for a number of chemistry instructors to teach the course to a large number of students before any worth while conclusions can be drawn.

CHAPTER 2

CHEMISTRY ACTIVITY UNITS

Unit 1

WATER

Introduction

Because everyone is familiar with water it is the logical chemical substance with which to begin a study of chemistry. But although it is familiar to everyone, students just starting a course in chemistry have many things to learn about this familiar liquid. Besides becoming familiar with its importance in a general way, its source, and how it is purified, there are many uses due to its physical properities that should be common knowledge to everyone.

After decomposing water, a student is immediately ready to study two of the most important and interesting elements or gases, namely, oxygen and hydrogen. There is no more logical place than here to acquaint the student with the meaning of a chemical element and compound. Water is first decomposed into its two elements, and then one can burn hydrogen in air where it combines with oxygen to again form water.

After a study of this unit the student will not only know more about water as far as it concerns his everyday life but will know its composition and the various ways in which its components are of tremendous importance. Water will no longer be a substance taken for granted but will be looked upon with all the respect due it.

Chapter I -- Importance and Purification of Water

A. Importance

Under the importance of water would come a study of the importance of water to plant and animal life in general. Then would follow a study of the importance of water to the growth and continued good health of the animal and human body. The place of water in circulation of the blood, digestion of foods, elimination of waste, as well as the importance of water in cell composition should be emphasized. A similar study of water in plant life should be made. The importance of water in the air as humidity for animal comfort should be mentioned, as well as the study of its importance in industry.

B. Source of Water

Under source should come a study of the underground systems of water as well as the ground or surface systems. Water in the form of a gas in the air or in the form of clouds should be taken up.

C. Purification of Water

The very important study of water purification should be taken up now. First the causes of water pollution should be studied, stressing pollution of wells and other sources of water for human or animal consumption. This should be followed by methods of purifying water. In this connection, students should be taught to understand what constitutes safe or good water.

Chapter II -- Water

A. Composition of Water

In order to understand what water is, the first step would be to decompose water by means of an electric current passed through water containing sulphuric acid. Before performing this experiment the instructor should, by means of a lamp board, show why sulphuric acid was used in the water. The electrolysis apparatus could be a Hofmann apparatus or a similar one. From electrolysis of water would be obtained the two gases, oxygen and hydrogen. Before taking up the study of these two elements, water should be studied further as a unit.

B. Properties of Water (Physical)

Under this topic should come the study of the freezing and boiling points of water. The laboratory work could include actual finding of freezing points and boiling points of water, using simple apparatus throughout.

Under the physical properties of water it should be pointed out that because of these properties water is used as a standard of measurements. An example of this standard is used in the marking of our thermometers. Its freezing point and its boiling point are used as the standard points for all ordinary measurements of temperature. The density of water, one gram per cubic centimeter, is used as the basis for measuring specific gravity. Water, with a value of one, is also the standard for specific heat. Water is the unit, therefore, of heat and of heat capacity. It has the highest thermo capacity of any substance. Its ability to absorb heat in its large bodies of water during the warm seasons of the year and liberate it during the cold seasons is of great importance in equalizing the climates of many regions near the large bodies of water. Heat of fusion and heat of condensation of water should become familiar terms to the student.

C. Water as a Solvent

During the study of water as a solvent the saturation point should be studied as well as solubility changes of water as a liquid with temperature, and as a gas with pressure.

D. Analysis and Synthesis of Water

As analysis of water was carried out in Chapter 2, it would not be necessary to repeat it here, but the synthesis of water by weight should be carried out. When dry hydrogen is passed over a weighed quantity of copper oxide which is heated, water (steam) and copper will be obtained. This experiment should be carried out to prove the Law of Definite Proportions.

Chapter III -- Oxygen

A. Preparation

The study of oxygen would include first the preparation from mercuric oxide and then potassium chlorate and manganese dioxide. That would be followed by a study of chemical and physical properties. The meaning of an element and a compound could be proven by heating mercury in air and burning wood. Also, the meaning of a physical and chemical change could be proven by using water and ice and showing the results of the rusting of iron.

B. Oxygen in Life

Continuing the study of oxygen would include studying oxygen in life. This would take up slow oxidation, ordinary burning, oxidation in the body, spontaneous combustion and oxygen in relation to the decay of matter.

C. Oxygen in Commerce

A brief study of commercial oxygen and its uses would conclude the study of oxygen at this point.

D. Carbon Monoxide

The student should be made to understand how incomplete oxidation of carbon may form carbon monoxide. The effect of this gas on the human body should be studied as well as the dangers of this gas in life experiences.

Chapter IV -- Hydrogen

A. Preparation

Preparation of hydrogen should include preparation from hydrochloric acid and zinc as well as preparation by deoxidizing steam.

B. Physical and Chemical Properties

After preparing the hydrogen gas, its physical properties can easily be shown, followed by its chemical properties. At this point the hydrogen gas should be burned to produce water. This will serve to connect Chapters I, II, and III of this Unit 1.

C. Commercial Importance of Hydrogen

This study should include the commercial uses of hydrogen in balloons, hydrogenation processes and oxyhydrogen torches.

D. Hydrogen Peroxide

Under the study of hydrogen should come the study of hydrogen peroxide. This would include preparation and commercial uses.

E. Law of Multiple Proportions

As a conclusion of this chapter would come a study of the Law of Multiple Proportions, using water and hydrogen peroxide as the proof.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 35-87, 618, 647-653.

Brownlee and Others, First Principles of Chemistry, pp. 45-60, 12-29, 30-44.

Black and Conant, New Practical Chemistry, pp. 60-75, 31-45, 46-59.

Emery and Others, Chemistry in Everyday Life, pp. 77-94, 26-38, 39-48.

Gordon, Introductory Chemistry, pp. 12-76, 231-248.

Horton, Modern Everyday Chemistry, pp. 109-117, 23-32, 123-132, 133-143.

McPherson, Henderson, Fowler, Chemistry for Today, pp. 76-83, 32-50, 51-61.

Wilson, Descriptive Chemistry, p. 26-33, 173-180.

Unit 2

ATMOSPHERE

Introduction

Atmosphere is most commonly thought of as being necessary chiefly because it is the common source of oxygen which animals and humans need.

Nitrogen which makes up the greatest portion of the atmosphere is often not thought of as being a necessity to life, but after this unit has been studied, the student will have had proof of how there can be no life without nitrogen. Some knowledge will be gained about the origin of soils as well as the important place the various nitrogen compounds play in our everyday environment.

Very often little consideration is given to the important part played by the other gases which help to make up the atmosphere. The student will gain new concepts of the part played by the water vapor, bacteria, dust particles, rare gases, and the small but very essential part of the atmosphere made up of carbon dioxide.

This unit on the atmosphere will include the study of ventilation and air conditioning which is so essential to our comfort and good health.

Chapter I -- Composition of the Atmosphere

The following table[1] shows at a glance the average composition of the air at sea level.

Table 1

Constituents of the Atmosphere

Substances	Percentages
Oxygen	21.00
Nitrogen	78.00
Argon	.94
Carbon Dioxide	.03 - .04
Water Vapor	variable
Dust	variable
Hydrogen	less than .01
Rare gases collectively	.001556

A study of how each of these is related to life should be made. Oxygen has been studied in Unit 1, Chapter III, but should be reviewed here.

Chapter II -- Nitrogen

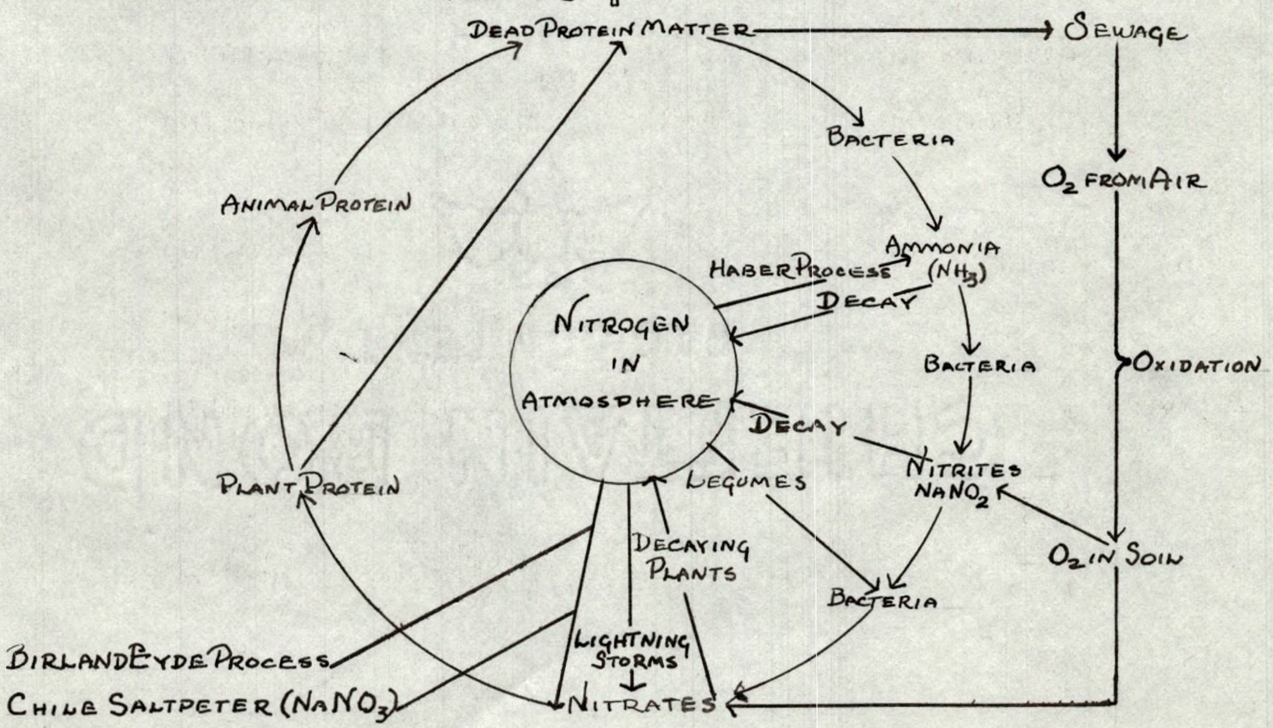
First a study is made of fixed and free nitrogen; secondly, its importance to life is pointed out. This

[1]Horton, Modern Everyday Chemistry (1937), p. 53.

will include proof of how there can be no life without nitrogen, also show how there is nitrogen in all living matter. Then it must be pointed out how neither plants nor animals can utilize free nitrogen. During this study it is shown how plants get their nitrogen in the form of nitrates, how all nitrates are soluble, absorbed through their roots and built into plant tissue. It must be shown how nitrates in soil form free nitrogen in air. This brings up the origin of soil, which would include a study of how oxygen plus nitrogen in the air forms oxides of nitrogen; then how nitric acid plus the lime in the soil produces an important ingredient of the soil. The nitrogen cycle would be taken up at this point.

DIAGRAM 1

NITROGEN CYCLE



The nitrogen cycle as depicted in the diagram should be studied in order to connect the entire topic of nitrates and nitrification.

Chapter III -- Important Compounds of Nitrogen

A. Ammonia

1. General

This compound should be considered first because it is the simplest of the nitrogen compounds, being made up of nothing but nitrogen and hydrogen. Under a study of the nitrogen cycle its formation from the decay of organic matter should have been explained. Its solution in water, commonly known as ammonia water and sold by grocers under the name of ammonia, is used in our homes as a cleansing agent.

2. Preparation

Both the laboratory and commercial preparations of ammonia should be taken up. The laboratory preparation should be carried out as an experiment. Under the commercial preparations, the Haber process, mentioned under a discussion of the nitrogen cycle, should be studied. The second commercial preparation, namely from coal, should easily be understood after carrying out the laboratory experiment of destructive distillation of soft coal. This is the most important source of commercial ammonia.

3. Properties

Both physical and chemical properties of ammonia should be brought out when ammonia is prepared in the laboratory.

4. Uses

The chief use of ammonia which should receive careful consideration is in cold storage plants and in the manufacture of ice. After studying the reasons why ammonia can be used in this connection several examples of its use in this field can be pointed out. This would include cold storage plants, ice manufacturing plants for sale of ice and for ice skating rinks in heated buildings and in warm weather for hockey games, skating exhibitions, etc.

5. Ammonium Salts

The preparation of ammonium salts from ammonia could be mentioned as well as the test for ammonium salts.

B. Acids of Nitrogen

1. General

A statement can be made that nitrogen combines with hydrogen and oxygen to form a number of acids of which nitric acid is the most important. It is a liquid, very active as an acid, and, therefore, never found free in nature. Some of its salts occur in nature, especially sodium nitrate.

2. Preparation of Nitric Acid

The laboratory preparation of taking sulphuric acid and sodium nitrate should be carried out in the laboratory. This preparation should be emphasized because most of the commercial nitric acid used in the United States is prepared in this way. The more recent method of preparing nitric acid from the air as well as the Cyanamide process should be mentioned.

3. Properties (Chemical)

The chemical properties of nitric acid should include its acid properties, oxidizing action and its action on metals.

4. Uses

Nitric acid has countless uses in the industries and in the chemical laboratories. It is used extensively in the manufacture of explosives, celluloid, photographic films and dyes. Most of these products will be discussed more in detail under a unit of cellulose products.

C. Oxides of Nitrogen

1. Nitrous Acid

The preparation and properties of nitrous acid should receive only limited consideration.

2. Nitrous Oxide

The preparation, properties and uses of this oxide should be taken up. This oxide should be prepared in the laboratory where its properties could be indicated.

3. Nitric Oxide

The preparation and properties of this oxide should be studied only briefly.

4. Acid Anhydrides

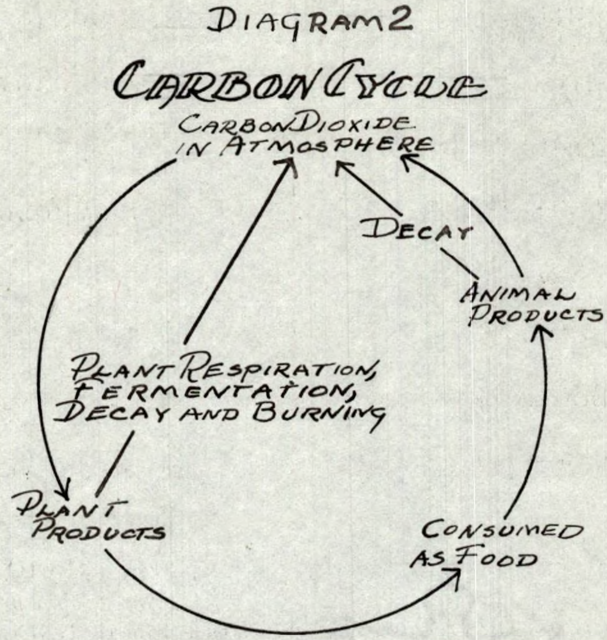
The oxides, nitrogen trioxide and nitrogen pentoxide, should only be mentioned in connection with its relation to the acids of nitrogen.

Chapter IV -- Other Gases in the Atmosphere

A. Carbon Dioxide in Air

There should first be a review of Unit 1, and at the same time the students should be shown how important .04 of 1% of the atmosphere which is carbon dioxide is to plant growth. This would be demonstrated by means of the carbon cycle.

A study of photosynthesis should now be made, using plant life to show how it takes place and testing for the presence of starch and carbon dioxide from growing plants.



B. Water Vapor

A study of precipitation should be made, including formation of clouds and fogs leading to a study of humidity and its relation to comfort. Laboratory work would include a study of dew point and wet and dry thermometers. This would lead to the topic on ventilation, both old and new theories. Under the problem of ventilation would come the study of how excess heat comes from the body, how the perspiration evaporates into the air, how this evaporation is a cooling process, and finally how the body is cooled by conduction, evaporation of perspiration and radiation.

C. The Role of Dust

Dust should not be discussed as an unnecessary impurity of the air but as a nuclei of clouds and as a diffusor of light.

D. Bacteria

Bacteria in the air may be the course of spreading plant and animal diseases which will be studied in another unit, but these bacteria and their part in the process of decay should be noted.

E. Air Conditioning

A study of the general methods employed in air-conditioning plants should be discussed.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 235-256, 87-90.

Brownlee and Others, First Principles of Chemistry, pp. 311-326, 327-350.

Black and Conant, New Practical Chemistry, pp.262-293.

Emery and Others, Chemistry in Everyday Life, pp. 477-485, 49-63, 95-111.

Gordon, Introductory Chemistry, pp. 105-149, 415-422.

Horton, Modern Everyday Chemistry, pp. 44-55, 268-277, 336, 195, 388.

McPherson, Henderson, Fowler, Chemistry for Today, pp. 221-236, 237-253, 145-157.

Wilson, Descriptive Chemistry, pp. 23-57, 121-131, 278, 80-82, 121-139.

Unit 3

ACIDS, BASES, AND SALTS

Introduction

A person cannot make very great progress in the study of chemistry without becoming familiar with the three classes of compounds called acids, bases, and salts. Very often it is found that students have little knowledge of the importance of these substances to their everyday existence.

It should be the purpose of this unit to become familiar with the more common acids, bases, and salts and to learn the importance and general properties of each. Because each of these chemical substances will be taken up later and the more important types of each prepared and studied individually, the study should be general in nature. But the unit should aim to acquaint the student with general information about the three most important classes of chemical compounds, so that little additional explanation will be necessary leter when they are taken up in other units.

Chapter I -- Acids

A. Importance of Acids

It should be pointed out that acids are very common in everyday life, being found in foods such as lemons, grape fruit, vinegar, sour milk, rhubarb and cherries. It should also be mentioned that they are found in the body, helping in the process of digestion. Other important places where acids are used include: treatment of burns, sanitation and industry, acids used in removing ink and rust stains, soft drinks, laboratory and experimental purposes, as well as countless uses in factories.

B. Classes of Acids

Acids belong to two great classes, one known as mineral or inorganic acids which includes the acids made from substances taken from the ground. It includes the three great laboratory acids--sulphuric, hydrochloric, and nitric. The second class is known as organic acids and includes most of the acids produced by living things or found in living things. These acids in general give certain foods their characteristic sour taste.

C. General Properties of an Acid

Under general properties should come the following:

1. Acids turn litmus from blue to pink.
2. Acids taste sour.
3. Acids react with certain metals, e.g. zinc, to form salts and hydrogen.
4. Acids neutralize bases.

D. General Preparation of Acids

In this connection this phase may only be mentioned in passing, because it will be taken up in detail as acids are treated individually in later chapters, but the fact can be pointed out that sulphuric acid is used in preparing any acid that does not have a high boiling point, because it (sulphuric acid) has a higher boiling point than most other acids.

Chapter II -- Bases

A. Importance of Bases

Bases are sometimes classed as alkalies (Arabian word meaning ashes). Ashes are still used as a common source of alkalies. Bases in many ways are directly opposed to acids in their chemical behavior. They are important chiefly because of their wide use in industry, especially in manufacturing soap, as a fertilizer, cleansers, as well as general caustics.

B. Common Bases with Great Commercial Value

Under the bases with great commercial value should be listed sodium hydroxide, commonly known as lye or caustic soda. Secondly should come potassium hydroxide, commonly called caustic potash. Both of these bases are commonly used in manufacturing soap. The third important base is calcium hydroxide or slaked lime. This base is very cheap in comparison with the others and is widely used in industry. It is widely used as a fertilizer for sour soils. The lime counteracts the acids in the soil and makes it better for growing crops. This process is commonly called sweeterning the soil. A fourth important base is ammonium hydroxide or ammonia water which is widely used as a common household cleanser. Ammonia and its use in refrigeration plants has been discussed. The last base that need be mentioned here is magnesium hydroxide, commonly called milk of magnesia. It is very commonly used by people with acid or sour stomachs to counteract the extra acid and make the contents of the fluids of the stomach normal or neutral.

C. General Properties of Bases

1. All bases are hydroxides. By this we mean they contain both hydrogen and oxygen.
2. Most bases have a bitter taste. This taste, however, is much less characteristic than the sour taste of acids.
3. Bases act on indicators. Acids turn litmus paper red, but the bases turn it back to blue.
4. Bases act on acids. The students have already learned that acids act on bases. This is shown to mean that there is an interaction between acids

and bases when they are brought together. The process is called neutralization because the distinguishing properties of both the acids and bases are destroyed. A spectacular demonstration may be made at this point to show the effects of the process of neutralization by taking the dangerous caustic sodium hydroxide or lye in solution and pouring it into the poisonous acid hydrochloric acid, stirring a moment and then drinking it. The students may be curious at this point and should be permitted to taste the solution, also to note that it has changed to a common salt water solution.

D. Preparation of Bases

The simplest way of preparing sodium hydroxide is to put a small piece of sodium on some water in an evaporating dish. Although this was done in the preparation of hydrogen, it could be repeated here. After the action stops, the solution should be evaporated to dryness and the white solid explained to be sodium hydroxide.

After this simple preparation of a base has been demonstrated, the commercial preparations should be taken up, especially the Castner process. The lye process should also be taken up, and it should be explained that the lye process is the oldest method of preparing sodium hydroxide and one of the oldest applications of chemistry to human needs. Calcium hydroxide is prepared by heating limestone to secure calcium oxide, and then whenever calcium hydroxide is needed, water is added to the unslaked lime. Magnesium oxide is prepared by heating magnesium hydroxide. This in water gives one milk of magnesia or magnesium hydroxide.

Ammonium hydroxide is prepared commercially by the destructive distillation of soft coal. This experiment should be performed now. The commercial process, which is known as the Haber process, should be studied.

Chapter III -- Salts

A. Importance of Salts

Salts are the largest group of compounds we have in chemistry, and therefore they are the most important class. The most familiar example is common table salt, but we cannot conclude that all salts resemble this one kind.

B. Properties of Salts

Salts are defined as compounds made up of the positive ion (metal, except NH_4) of a base and the negative ion of an acid. As this definition indicates, there is no common ion for salts as there is for acids and bases. Therefore salts have no common properties, although they often have certain similarities in taste, color or solubility. These similarities, however, as might be expected are most pronounced in salts obtained from the same metal or the same acid.

C. Class of Salts

Salts are classified as normal, acid, basic or mixed salts on the basis of the way they are formed.

D. Preparation of Salts

Salts are formed when the hydrogen of acids is replaced by metals. This may be done either by direct action of acids on metals or by the interaction between acids and metallic oxides or hydroxides. Most salts, however, are found in nature making up a large part of the crust of the earth and plentiful in waters of the sea. They are also found in the bodies of animals and in the tissues of plants. Common salt will be taken up later in a separate chapter.

Chapter IV -- Naming of Acids, Bases and Salts

A. Acids

All common acids contain either two or three elements. Those that contain but two elements are called binary acids and are given names consisting of the prefix hydro-, the name of the second element, and terminating in "-ic," e. g. hydrochloric acid and hydrosulphuric acid.

Acids that contain three elements are called ternary acids. Most of these contain oxygen in addition to hydrogen and get their name from the element other than oxygen and hydrogen because the three elements can unite in different proportions to form two or more acids. An explanation and examples of the ic, ous, per, and hypo acids should be made.

B. Bases

All bases are called hydroxides. They are distinguished by the metal present.

C. Salts

A salt derived from a binary acid is given a name consisting of the names of the two elements composing it with the termination "-ide." Examples: sodium chloride, ammonium chloride.

A salt of a ternary acid is named in accordance with the acid from which it is derived. A ternary acid terminating in "-ic" gives a salt ending in "-ate," while an acid terminating in "-ous" gives a salt with the name ending in "-ite." Examples of several salts should be given with the corresponding acid mentioned in each case.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 171-181, 183-190.
Brownlee and Others, First Principles of Chemistry, pp. 168, 289, 178-183, 332-333, 164-166, 496.
Black and Conant, New Practical Chemistry, pp. 149-156.
Emery and Others, Chemistry in Everyday Life, pp. 112-133.
Gordon, Introductory Chemistry, pp. 152-159.
Horton, Modern Everyday Chemistry, pp. 245-246, 252-255.
McPherson, Henderson, Fowler, Chemistry for Today, pp. 200-209.
Wilson, Descriptive Chemistry, pp. 110, 131-132, 140-142.

Unit 4

THEORIES, SYMBOLS, FORMULAS, EQUATIONS, AND CHEMICAL CALCULATIONS

Introduction

Too often over-emphasis is placed upon the study of chemical theories. This should be guarded against. The laws of chemistry that have been unchallenged for years should become familiar to the student. The laws should not merely be memorized but should be learned in such a way that they serve to connect up and explain the reasons for various chemical phenomena.

Symbols are the chemists shorthand and should become familiar to the student from the very beginning of the course. Symbols, formulas, and chemical equations should be brought in from the first, so by continual usage they become part of the student's general knowledge. The old plan of drilling students on symbols at one time, formulas another time, and equations at another time, serves to destroy the purposes of these to the student and does not serve to connect them with their proper places in the learning of chemistry.

Chemical calculations or problems are often stressed too much in high-school chemistry. To make the course practical, students should only be required to become efficient in solving weight problems and problems involving percentage composition.

Chapter I -- Matter and Its Kinds

First would come a definition of matter and an explanation of the law of conservation of matter, followed by the forms of matter and the composition or makeup of things. This will lead to definitions, explanations and illustrations of <u>elements</u>, <u>compounds</u> and <u>mixtures</u>. The electrolysis of water, giving hydrogen and oxygen as shown in Unit 1, Chapter II, could be repeated here. Then hydrogen could be prepared by using zinc and an acid, followed by burning of the hydrogen to form water again. Also, mercuric oxide could be broken up into mercury and oxygen, both of which could be identified. These experiments should make clear what the difference is between an element and a compound. Mixtures should be illustrated by mixing sand and salt or sugar and flour or salt and water. Air can be given as an example of a mixture. Everyone knows that the amounts of oxygen, water, carbon dioxide, dust, etc., varies from time to time, but still the mixture is air.

Chemical affinity or the question of why a chemical change occurs should be answered next. A good definition to use would be: Chemical affinity is that force which causes elements to unit and holds them in combination with each other. Valence should be brought in here. Valence number should be emphasized and valence taught from atomic numbers as well as from the structure of the atom. Atomic structure should be studied far enough to explain the atomic structure of a few of the simpler elements only. The relative abundance of the elements, with a brief study of the occurrence of the elements can be covered. Elements in living things can be made more clear by the following table.[1]

Table 2

Average Composition of the Human Body

Element	Per Cent	Element	Per Cent
Oxygen	65.00	Sodium	.15
Carbon	18.00	Chlorine	.15
Hydrogen	10.00	Magnesium	.05
Nitrogen	3.00	Iron	.004
Calcium	1.50	Iodine	.00004
Phosphorus	1.00	Fluorine	traces
Potassium	.35	Silicon	traces
Sulphur	.25	Other Elements	traces

The study of the names of the elements leads to the chemist's shorthand, namely, symbols. Symbols should be

[1] McPherson, Henderson and Fowler, Chemistry for Today, p. 25.

brought into use as soon as possible so that the students gradually become acquainted with them for the different elements as they are studied. In studying symbols the meaning of atoms and molecules must be introduced. This leads to chemical formulas and chemical equations, all of which should be studied in their logical sequence.

Chapter II -- Theories

A. Atomic Theory

No detailed study of the atomic theory should be made any place in this course. The reason for this is chiefly because scientific knowledge of the structure of the atom is changing so rapidly that there is no need of studying a theory today that may be changed entirely tomorrow. The only study of the atomic theory should be made to explain how matter is made up of atoms.

B. Dalton's Theory

Dalton's theory was first a hypothesis because it was a guess at the explanation of some fact or facts. It became a theory when it was partly or largely verified by facts. Dalton's theory may be studied briefly.

C. Law of Definite Proportions

This law can best be illustrated and explained by the electrolysis of water or by the following experiment:

1. Weigh some copper oxide.
2. Pass over the heated copper oxide some hydrogen (which is not weighed).
3. Collect carefully all the water which is formed and weigh it.
4. Weigh the residue of the copper oxide. The loss of weight of the copper oxide will, of course, be the weight of the oxygen which was removed by the hydrogen. The hydrogen is dried by passing through concentrated sulphuric acid, and all the water is absorbed in calcium chloride so none escapes.

D. Law of Multiple Proportions

This law was studied and illustrated in Unit 1, Chapter IV, but should be reviewed now.

Chapter III -- Chemical Calculations

A. Solving Weight Problems

This type of problem is of such practical value to the chemist that the student should be thoroughly drilled in it. If a chemist wants to prepare a certain amount of a substance he should know how much of a substance to take to obtain that certain amount, or if a chemist takes a known amount of some known compound and decomposes it, he should be able to determine not only what substances are obtained but how much of each one by weight calculation. A third example of this type of problem would be to determine how much by weight of a certain substance would be needed to completely react with a known amount of some chemical substance.

B. Problems in Percentage Composition

A sufficient number of percentage composition problems should be solved so the student becomes familiar with the general method used.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 107-122.
Brownlee and Others, First Principles of Chemistry, pp. 168, 178-183, 289.
Black and Conant, New Practical Chemistry, pp. 89-118.
Gordon, Introductory Chemistry, pp. 78-103.
Horton, Modern Everyday Chemistry, pp. 33-42, 57-68.
McPherson, Henderson, Fowler, Chemistry for Today, pp. 158-163, 108-134, 24-25, 90.

Unit 5

SULPHUR, ITS COMPOUNDS AND USES

Introduction

Sulphur is familiar to most every person, but not many know the importance of sulphur and the large number of uses made of it and of its compounds. Sulphur has been used for hundreds of years as an ingredient of gunpowder, and because of its ability to combine readily with oxygen it has been used extensively in manufacturing matches and fireworks.

The method most commonly used for extracting sulphur from the ground should prove interesting because of its simplicity and efficiency.

The preparation and uses of sulphuric acid should receive the most emphasis in the study of this unit. The use of sulphuric acid in industry is steadily increasing as synthetically made products are growing in number and quantities used.

Sulphur has many compounds besides sulphuric acid that are of great importance and when studied should aid the students in getting a clearer understanding of many of the substances in common everyday use but heretofore taken more or less for granted without any attempt having been made to answer the question of where they were obtained.

Chapter I -- Origin, Source and Uses

Almost everyone knows what common roll sulphur looks like. Further interest in sulphur may be created by, first, melting roll sulphur, second, by pouring into folded filter paper, third, boiling some in a hard glass test tube and last by pouring boiling sulphur into cold water.

After the student's interest has been aroused in sulphur he should study why sulphur is important as an element. He should be told how two million tons of the familiar yellow element are used each year in various processes of industry. Matches, gunpowder, insecticides and rubber are a few of the important products using sulphur as an important ingredient. Practical uses of sulphur have been known for a long time. People three thousand years ago made frequent reference to the fire and brimstone of the infernal regions. This is because men of olden times regarded sulphur as the basis of all fire.

The sources of sulphur should be studied next with special emphasis placed on the Frasch method of extracting free sulphur. It should be pointed out that sulphur occurs in common compounds such as chalk and calcium sulphate and epsom salt or magnesium sulphate. Sulphur compounds are also present in certain plants such as garlic, onions, and cabbage, and in a number of animal products such as wool, horns, hoofs, hair, blood, and the yolks of eggs.

Allotropism should be studied with sulphurs. Three allotropic forms, namely, rhombic, prismatic and plastic are typical examples.

The uses of sulphur are varied. It has been used for hundreds of years to make gunpowder by mixing charcoal and potassium nitrate. Its great affinity for oxygen is especially valuable in such a mixture. For this reason it is used a great deal in manufacturing matches and fireworks. Sulphur plays an important part in the making of rubber. By heating sulphur with other substances a process known as vulcanization takes place. The importance of this process cannot be over estimated because it makes possible the making of rubber automobile tires and many other desirable rubber products. The sulphur tends to toughen and harden the rubber and makes it less sticky and more elastic. Another use of sulphur is accomplished by boiling with a solution of lime to make an effective fungicide known as lime sulphur spray. This spray is used on fruit trees as a protection against various plant diseases.

Chapter II -- Sulphur and Sulphuric Acid

It has been said that a nation's extent of being civilized can be measured by the quantity of sulphuric acid it uses. Therefore, the use of sulphur in making sulphuric acid is its most important use. This acid enters directly or indirectly into the manufacture of most articles today. It enters into the production of many other products which in turn have many important uses. It helps in the manufacture of other acids, lead storage batteries, phosphate fertilizers, explosives, dyes, celluloid, cloth, in the cleaning of steel for galvanizing and tinning, in the refining of gasoline, lubricating oils and many metals, and in the preparation or purification of chemicals. The following table shows the quantities used annually in the United States for commercial purposes.

Table 3

Sulphuric Acid in Industry[1]

Industry	Quantity Used (in tons)
Fertilizer manufacture	1,800,000
Petroleum refining	1,500,000
Manufacture of other chemicals	1,200,000
Steel industry	700,000
Manufacturing of metals other than steel	500,000
Storage batteries	200,000
Textiles and explosives	300,000
Minor uses	400,000

[1]Biddle and Bush, Dynamic Chemistry, p. 292.

Sulphuric acid should next be compared with other acids. Because acids have been studied in a general way before, it need only be pointed out how sulphuric acid has the typical properties of a strong acid and how it compares with nitric and hydrochloric acids.

Sulphuric acids great attraction for water should receive special emphasis. This attraction for water is one of its best known properties as well as one of its most valuable ones. Examples of this action could be shown by pouring concentrated sulphuric acid on sugar, wood or paper. It should be explained that the charred appearance is due to the fact that these materials are all hydro-carbons made up of carbon, hydrogen and oxygen. Sulphuric acid assists in many cases in completing a chemical process by withdrawing water from a substance. An example of this procedure takes place when the explosive nitroglycerine is produced by combining glycerine with nitric acid. This reaction cannot take place except when sulphuric acid is used to withdraw the water and thereby assist in completing the reaction.

Because sulphuric acid is used often in dilute form, students should be cautioned how to properly dilute the acid by always pouring the acid into the water and never the reverse. A fairly safe rule to follow in mixing liquids is, unless other directions are given, pour the heavier liquid into the lighter one.

The manufacturing of sulphuric acid brings us up to the most important use of sulphur. The acid is manufactured by two leading methods of production, namely, the contact process and the lead-chamber process. Because the contact process is the newest and most generally used method for the production of sulphuric acid this process should be studied in detail.

Because the lead-chamber process is not used very much it need not be studied in detail, if at all.

Chapter III -- Other Compounds of Sulphur

The gas sulphur dioxide is not common in nature except in volcanic eruptions but has important properties and therefore should be taken up. Its preparation and uses should also be studied. Because its preparation has been studied in the first step in the manufacturing of sulphuric acid it need not be repeated here, but its important uses which result from its reducing or deoxidizing property should be pointed out, such as its use in bleaching straw, silk and wool and in preserving such foods as dried fruits or cherries or corn for canning. Sulphur dioxide's use as a refrigerant should be mentioned as well as the reason why it can be used in this respect, because it is easily changed to a liquid by compression and cooling.

Hydrogen sulphide should first be pointed out as the gas that gives rotten eggs their foul odor. It should also be mentioned as being present in sulphur waters. Any students who have visited Yellowstone Park can be asked to recall their experience with the sulphur springs and mud volcanoes. All students have had experience with hydrogen sulphide in connection with the decay of dead plants and animals. The properties of hydrogen sulphide should be studied. The use of hydrogen sulphide in analysis is very important because it is used so extensively. The sulphates, sulphites and sulphides all have their place in the study of sulphur.

The sulphide of carbon, known as carbon disulphide, should be studied because it is used extensively in industry, especially in manufacturing rayon and a number of other stustances. Its use in preparing carbon tetrachloride and in the extermination of ants, mice, rats and other pests is important.

The tests for identifying sulphates, sulphites and sulphides should be carried out in the laboratory. If matches were not studied under oxygen in Unit 1, an interesting study of their construction can be made to close this unit. Interesting laboratory work can be carried out on the topic of matches.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 286-305.
Brownlee and Others, First Principles of Chemistry, pp. 209-240.
Black and Conant, New Practical Chemistry, pp. 187-216.
Gordon, Introductory Chemistry, pp. 179-204.
Horton, Modern Everyday Chemistry, pp.277-287, 412-414.
McPherson, Henderson, Fowler, Chemistry for Today, pp.262-287.
Wilson, Descriptive Chemistry, pp. 111-121, 199-200.

Unit 6

COMMON SALTS AND COMPOUNDS AND ELEMENTS FOUND IN HOME

Introduction

The expression, "The salt of the earth," when used in reference to some very dependable individual has its foundation no doubt from the fact that salt is one of our most common substances and one that has been known to man for centuries. Salt is also one of the necessities for animal life. Common salt, sometimes referred to as table salt or by chemists as sodium chloride, was the first representative of its class to become familiar to man.

Students' interest in common salt becomes aroused when they begin to see how important it is to life. A desire to know more about it is created when salt is decomposed to form sodium, an element so active that it must be kept under kerosene, and chlorine, a gas which can be used as a deadly poisonous gas.

After the students have become familiar with the various uses and properties of the salt itself, the study of the various compounds made from common salt takes on added importance. Often familiar substances are used without any questions being asked as to where they came from; hydrochloric acid, lye, washing and baking sodas are just a few examples. A new interest in these substances will be aroused after studying this unit.

Students living in larger cities often take it for granted that the city water supply will be pure, and the rural resident oftens uses a carbon tetrachloride fire-extinguisher without knowing what is inside the metal container, but these things will be understood after completing this unit.

Chapter I -- Common Salt

A. Importance

Although salts were mentioned in Unit 3, sodium chloride or common salt is found so abundantly and used so extensively that it should be studied in a separate unit. One may drive for miles over solid salt in Utah. Rock salt is found in many countries, but the largest deposits are those in New York, Louisiana, Austria, Jugoslavia, Germany and Spain. Often in these beds the salt is of such purity that it has only to be mined and crushed to be ready for use. The method of securing salt from salt wells should be studied as that is a very common method of securing salt when it lies too deep under the surface to make mining practical.

The amount of salt in the ocean is of interest and importance. The extraction of salt from sea water should be taken up, as it is an important process in warm climates.

B. History

Common salt is the first representative of its class to become familiar to man. When other compounds with properties similar to common salt became known, they were given the name of salts. Further study of the history of salt would be useful.

C. Properties

Properties of common salt should be studied. The difference between common salt and other salts in properties should be noted.

D. Uses

Under uses of common salt should come the preserving of meat, refrigeration plants, seasoning of food, and the necessity of salt to animal life.

Chapter II -- Compounds Made from Common Salt

A. Hydrochloric Acid

1. Preparation

Because common salt and sulphuric acid have been studied before this, the preparation of this acid by using sodium chloride and sulphuric acid would be a natural sequence.

2. Physical and Chemical Properties

The physical properties of hydrogen chloride should be taken up first, followed by the chemical properties of hydrochloric acid.

3. Uses of Hydrochloric Acid

Such important uses of the acid as the making of chlorides, cleaning metals, manufacturing of glue, gelatine and glucose should be studied. The use of the acid in the human stomach as a part of the gastric juice should be noted as well as its use in medicines for certain types of indigestion.

4. Test for Chloride Ion

Because one of the most important uses of hydrochloric acid is to make chlorides, the test for the chloride ion should be studied now and carried out in the laboratory.

B. Caustic Soda or Sodium Hydroxide

1. Importance

The importance of caustic soda can best be seen by a study of the following table.[1]

Table 4

Caustic Soda Used in the United States (Annually)

Industry	Amount Used (in tons)	Industry	Amount Used (in tons)
Soap	97,000	Textiles, other than rayon	37,500
Petroleum refining	90,000	Rubber reclamation	35,000
Rayon	78,000	Vegetable oils	11,000
Chemicals	82,000	Pulp and paper	33,000
Exports	60,000	Miscellaneous	39,000
Lye	32,000	Estimated Total	595,000

[1] Horton, Modern Everyday Chemistry, pp. 251-259.

2. Preparation

The simplest way of preparing sodium hydroxide is to put a small piece of sodium on some water in an evaporating dish. If this is done in preparing hydrogen in Unit 1 it could be repeated here. The commercial preparation of caustic soda is by the electrolysis of brine. This process is closely associated with the manufacture of chlorine which will be taken up later. Several types of apparatus are used of which the Castner, the Nelson, the Castner Kellner and the Vorce processes are examples. Only one of these apparatuses need be studied, preferably the Castner process (if not already taken up in Unit 3).

3. Uses

The uses of caustic soda are pointed out in the table under importance and will be taken up in different units later on.

C. Chlorine

1. Preparation

The preparation of chlorine commercially should be of importance because of the large amount of chlorine used and because it is prepared by the electrolysis of brine. The Nelson cell should be explained and studied in detail. The laboratory preparation of chlorine should be carried out by the instructor as a class demonstration because of the danger of chlorine gas as a poison.

2. Uses of Chlorine

The chief use of chlorine is as a germicide in drinking water. Another important use is as a bleaching agent. This use should be demonstrated in the laboratory.

The use of chlorine as a disinfectant should be mentioned as well as its use in making carbon tetrachloride used as a solvent and as a material for fire extinguishers, chloroform used as an anesthetic, sulphur chloride used in vulcanizing rubber as well as for making many organic compounds used as dyes and medicines. Chlorine is also used in the extraction of metals from their ores.

D. Sodium Bicarbonate and Sodium Carbonate

1. Preparation

Because the natural supply of sodium and potassium carbonates is very limited, the Solvay process of making soda should be taken up. This process should be understood quite easily, because ammonia, water and carbon dioxide have already been studied. These compounds together with common salt result in the formation of sodium bicarbonate. The practical operation of the Solvay process, its products and its economy as a commercial preparation of soda should be taken up.

2. Uses of the Two Carbonates

Sodium bicarbonate is most commonly used as a baking soda from which it gets its name. Sodium carbonate is most commonly used as a washing compound from which it gets its name, washing soda. The reason should be pointed out why one carbonate works better as a baking compound and the other better as a washing compound. The uses of sodium carbonate in the refining of petroleum are also important. The use of sodium bicarbonate in chemical fire extinguishers, baking powders, and in the making of effervescent salts should be emphasized.

F. The Chlorine Family

Because the bromides and iodides are so closely associated with chlorine they could very logically be studied in this unit.

<u>TEXTBOOK REFERENCES</u>

Biddle and Bush, <u>Dynamic Chemistry</u>, pp. 209-223,369-387.
Brownlee and Others, <u>First Principles of Chemistry</u>, pp. 105-118, 167-174, 287-303, 351-367, 517.
Black and Conant, <u>New Practical Chemistry</u>, pp. 119-128. 339-344.
Gordon, <u>Introductory Chemistry</u>, pp. 205-217.
Horton, <u>Modern Everyday Chemistry</u>, pp. 242-260.
McPherson, Henderson, Fowler, <u>Chemistry for Today</u>, pp. 177-191, 297-305.
Wilson, <u>Descriptive Chemistry</u>, pp. 111-121, 199-200.

Unit 7

FUEL RESOURCES

Introduction

Coal or other fuel is often placed in a burning stove or furnace in order to help keep us warm, without any thought being given as to why it keeps us warm or why it burns to give heat. Gasoline is placed in the gasoline tank of an automobile, the motor started and the car driven for miles without any thought being given as to why gasoline will serve to keep the motor going and so aid to propel the car. Not only do most people fail to give these reactions a thought, but if they were asked to explain why they took place, they would be unable to do so.

Some people prefer one fuel to others, but there must be a reason for this, and so the question is raised as to the advantages and disadvantages of different kinds of fuels.

Before one can understand how or why fuels act as they do when being used, something must be known of their composition and properties.

Often the question is asked why certain fuels cost as much as they do in comparison with other fuels. A study of the sources of various fuels and the processes gone through in their preparation will serve to clarify this question.

Chapter I -- Kinds of Fuels

Fuels may be divided into:

A. Solid fuels, further divided into:

1. Natural fuels, including wood, peat, lignite and coal.
2. Carbonized fuels, as charcoal and coke.
3. Compressed fuels,as briquets or patent fuel.

B. Liquid fuels as petroleum, benzene, benzol and alcohol.

C. Gaseous fuels including:

1. Natural gas.
2. Gas produced by carbonizing solid fuels, as coal gas.
3. Gas produced by partially burning solid fuels, as water gas, producer gas and blast furnace gas.
4. Gas produced by chemical action for special purposes, as hydrogen and acetylene.

Chapter II -- Value of a Fuel

The value and importance of any fuel depends upoh its distribution, cost, calorific value and nature of its combustion. These various points should be taken up. A laboratory exercise should be carried out to show what is meant by B. T. U., so often spoken of in connection with fuels.

Chapter III -- Properties of Different Types of Fuels

A. Solid Fuels

1. Natural Solid Fuels

Under this should come the origin, namely, cellulose. Wood with its advantages and disadvantages as a fuel should be discussed. Then peat, lignite, bituminous and anthracite coal should be taken up in the order mentioned and studied from the view point of composition, advantages and disadvantages as a fuel.

2. Carbonized Fuels

Under this should come a study of charcoal and coke.

3. Compressed Fuels

Briquets can be mentioned as the only important example of compressed fuels, but the briquets are not all made from the same materials, and therefore a study should be made of some of the more important kinds of briquets. Briquets as a fuel are steadily increasing in importance and for that reason should be given consideration.

B. Liquid Fuels

1. Crude Petroleum

Because crude petroleum is rapidly becoming our most important fuel it should receive very thorough study. It should be studied first as to where found and how obtained from its supply in the ground; then a study of the refining process should be taken up with a study of the products obtained and their uses.

A very clear picture of fractional distillation should be made by means of a laboratory experiment. To make it more easily understood, a mixture of gasoline, kerosene, melted paraffine, benzene, and glycerine could be prepared and then separated by fractional distillation.

C. Gaseous Fuels

1. Natural Gas

This fuel is found in widely spread areas and therefore may be familiar to some of the students. Its composition should be the most important study.

2. Coal gas

This gas is still the most common of our gaseous fuels and for that reason should be given most detailed study. Its preparation should be considered first and then its composition. Under composition should be noted the average amount of gas obtained from a ton of bituminous coal and the kinds and amounts of by-products. A simple laboratory experiment in the destructive distillation of soft coal, with the products obtained, should be carried out.

3. Producer Gas

The method of preparation and the composition of the gas is important. The use of this gas as a fuel should be easily understood when the student remembers the combustibility of hydrogen and carbon monoxide, studied in Units 1 and 2.

4. Blast Furnace Gas

Because the blast furnace method of smelting iron ore has not been studied yet, the method of preparing this gas should only be mentioned. The composition and use of the gas should be taken up.

5. Water Gas

A study of the preparation and composition of this gas should be made. The usefulness of this gas should be easily understood by the student as was the case of producer gas.

6. Carbon Monoxide

Carbon monoxide is a necessary part of most fuel gases and often a product of any burning fuel if there is incomplete combustion; therefore, a study of this compound should be taken up again in this unit. Because it forms carbon dioxide when it completely burns, a study of carbon dioxide could be made. Fuels lead to fire, so the use of carbon dioxide in fire extinguishers should be studied with the necessary laboratory experiments. The use of carbon dioxide as dry ice will be taken up in another unit.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 597-618, 647-653.
Brownlee and Others, First Principles of Chemistry, pp. 401-406, 433-449, 412-419.
Black and Conant, New Practical Chemistry, pp. 358-367, 423-442, 217-238.
Emery and Others, Chemistry in Everyday Life, pp. 525-553.
Gordon, Introductory Chemistry, pp. 423-427, 459-466.
Horton, Modern Everyday Chemistry, pp. 169-216.
McPherson, Henderson, Fowler, Chemistry for Today, pp. 316-321, 350-371.
Wilson, Descriptive Chemistry, pp. 58-109, 65.

Unit 8

FERTILIZERS, NATURAL AND COMMERCIAL

Introduction

For an agricultural section a study of fertilizers should be not only interesting but also useful. There is no doubt that the subject of fertilizers will increase in importance if the country continues to depend upon agriculture for its existence.

Fertilizers will have no apparent meaning if the necessity of applying various types of fertilizers to the soil is not clearly understood. Various plants or foods derived from plants should be listed to show the presence of various elements such as nitrogen, potassium, and phosphorus. Because plants secure their food from the soil, the logical conclusion will be that certain materials must be supplied to the soil from time to time if the soil is to continue to furnish all good required for plant growth.

In order for fertilizers to have any practical use one must know something about the makeup of soils and in what ways soils may vary in composition. Commercial fertilizers should be obtained to find out their composition, so that the students can determine when fertilizers are needed, what kind to buy and how to apply them to secure the best results.

Chapter I -- Soils and Fertilizers

A. Formation of Soils

The formation of soils was taken up under nitrogen in Unit 2, Chapter II, but should be reviewed here with a more detailed study.

B. Different Kinds of Soils

After a study of the formation of soils, it follows naturally that the different kinds of soils, including limestone, sandy, clay and acid soils, should be studied. The physical properties of soils should be studied. These physical properties cause soils to be different just as much as composition.

C. Natural Plant Foods

Under natural plant food would come weathering of rocks, decaying of leaves, annual plants, and the bodies or excreta of animals. The decay is brought about by bacteria, molds, and other fungi. Leaf mold or humus is the name given to this decayed matter which forms the dark covering of most soils spoken of as rich soils.

Chapter II -- Fertilization of Soils

A. Meaning of the Terms

The subject of fertilization of soils should deal with (1) the foods required for the growth of plants, (2) the analysis of soils, to learn whether these foods are present and in what proportion, (3) the analysis of commercial fertilizers to learn whether they contain the necessary foods in the proper proportion, and (4) the correct methods of applying the fertilizers to the soil in order to secure the best plant growth. Fertilizers should be studied with these four points in mind.

B. When Fertilization Is Necessary

The common practice of raising crops such as grain which contain more fertilizing constituents than the waste returned to the soil can be used as the outstanding example of why fertilizers are needed. Another example would be where the same crop is raised every year, decreasing fertility, producing a decrease in the crops without producing any decrease in the expense of seeding or in the labor necessary to raise them.

C. Elements Removed from Soil by Plants

The chief elements drawn from the soil are potassium, calcium, sulphur, phosphorus and nitrogen. Less important elements are silicon, magnesium, iron, sodium and chlorine. The natural weathering of minerals in the ground, together with decaying vegetation, usually provide these elements, but the common misuses of the soil mentioned before usually remove the supply of potassium, phosphorus and nitrogen.

This brings on the need of fertilizers, which are becoming more important every year. At first natural fertilizers were used, but as the land became worn out resort had to be made to artificial fertilizers.

D. Needs of Plants

Different soils require these elements in different proportions owing to different formation, or to different management and the crops grown. Sandy soil usually lacks all fertilizing elements, while clay soil usually contains mineral elements in abundance. Soils rich in vegetable matter may lack the mineral matter. Limestone soil usually contains phosphoric acid.

Table 5

Plant Constituents Found in the Soil[1]

Necessary	Unnecessary
Water	Sodium
Sulphur	Chlorine
Magnesium	Silicon
Iron	Manganese
Lime (sweetens)	
Nitrogen (stalk growth)	
Phosphoric acid (grain maturity quality)	
Potash (strength)	

The table shows the plant constituents found in the soil. Water must often be applied by irrigation.

1 Emery, Davis, and Others, Chemistry in Everyday Life, p. 467.

Different crops need these elements in different proportions, and unless care is taken to apply the right quantity much will be wasted because of excessive amounts used. Experiments on soils, crops and use of fertilizers should be carried out at this point to show the need of certain fertilizers in different cases and in different proportions.

D. Constituents of Fertilizers

Soils that have the necessary physical properties may be maintained by adding three substances: (1) nitrogenous matter, (2) phosphates of calcium and (3) compounds of potassium. It seems probable that the elements sulphur, manganese, iron and possible boron also are important in the growth of plants.

Chapter III -- Kinds of Fertilizers

A. Natural Fertilizers

These include barnyard manure and decomposing vegetable mould or muck such as straw, cornstalks, etc. A study should be made to determine which substances mentioned in Chapter II, section D, of this unit are contained in these natural fertilizers.

B. Artificial Fertilizers

1. Meaning of Artificial Fertilizer

This can easily be explained by the following definition: Artificial fertilizers are those manurial substances prepared from materials with some special treatment to render them fit for plant food.

The chief requisites of a good fertilizer are (1) it must contain at least one substance fit for plant food, and this substance must be easily convertible by rain and moisture to such a form that the plants can easily assimilate it, (2) it must be dry and finely powdered so that it will not deteriorate, and it may be evenly distributed over the surface of the ground, (3) it must contain nothing injurious to plant life, and (4) it must be cheap.

A complete fertilizer contains all three of the elements mentioned before, namely, potassium, phosphorus and nitrogen. They should be taken up separately.

2. Potassium Fertilizer

(a) Kinds--The four forms of potassium fertilizer most commonly used are potassium chloride, potassium sulphate, kainite and potassium carbonate (wood ashes). The first two are commonly called potash.

(b) Source--These potassium compounds are obtained principally from natural deposits in France and Germany with a limited supply from the United States. A valuable study could be made of the potash supply of the world.

(c) Use-- The use of potash as a fertilizer should be taken up. This will lead to a study of the use of potassium and potassium salts in general.

3. Phosphate Fertilizer

(a) Kinds--This should include calcium phosphate which may be obtained from the phosphates of calcium, iron or aluminum and occurs in three forms: (1) that which is readily soluble in water and easily used, (2) that which is slightly soluble in water and still used readily, and (3) that which is sparingly soluble.

(b) Source--Ground bones are a valuable source but too limited in amount. The chief supply comes from rock phosphates which contain about 70 per cent of calcium phosphate. These rocks come mostly from Florida and Tennessee. A brief study should be made of how the insoluble calcium phosphate is treated with sulphuric acid to change it into soluble calcium acid phosphate. Slag from the manufacture of steel is also a source of phosphorus fertilizer.

(c) Use--After taking up the use of phosphate compounds as a fertilizer, the use of phosphorus and phosphoric acid should be made.

4. Nitrogen Fertilizers

(a) Kinds--This should include ammonium sulphate, sodium nitrate, animal excrements, dried blood, fish scraps, tankage, bone meal, and cotton seed meal.

(b) Source--The source may be divided into three, namely, slaughter houses, mines and artificial compounds of nitrogen made by chemical or electrical processes. The chief source of sodium nitrate is in Chili, South America, where it was formed by an enormous supply of bird manure accumulating.

(c) Use--Besides taking up the use of nitrogen compounds as fertilizers a further study should be made of the uses of the nitrates. This would include the use of sodium nitrate to manufacture nitric acid and to make potassium nitrate. Then the uses of potassium nitrate should be made. The study of the nitrates as fertilizers and for other uses should help to review the study of nitrogen made in Unit 2.

Chapter IV -- Soil Analysis

A. What Is Soil Analysis

A study of what soil analysis is should be made and simple experiments made on different soils.

B. Importance of Soil Analysis

By means of field experiments, observation of plant growth can be made. This would bring up a study of crop rotation and how nature balances her chemistry of the soil if left alone to do so.

TEXTBOOK REFERENCES

Brownlee and Others, First Principles of Chemistry, pp. 401-406, 433-449, 306.
Emery and Others, Chemistry in Everyday Life, pp. 466-487.
Horton, Modern Everyday Chemistry, pp. 332-337.
McPherson, Henderson, Fowler, Chemistry for Today, pp. 316-321.

Unit 9

ALCOHOLS, ORGANIC ACIDS, AND ESTERS

Introduction

There is a great deal of variation in the amount of organic chemistry taken up in a high-school chemistry course. But a practical course in chemistry would be incomplete without a study of our two most common alcohols, our most common organic acids, and a few of our useful esters.

Students will be surprised to find out that ethyl alcohol ranks among the highest of our important chemicals because of the numerous uses of this chemical in preparing various products for commercial purposes.

A person will not understand the difference between animal fats and vegetable fats without a study of organic acids and fats.

Soap making at home has been a common source of supplying soap for general purposes in the home, but without a study of the organic chemistry of fatty acids and esters, soap making will be a mystery. Not only will a student know how soap is made, but he will intelligently know something about the different commercial soaps so as to buy on the basis of quality instead of because of clever advertising.

Most of our flavors and extracts are manufactured or synthetic. The meaning of synthetic products will become meaningful after this unit has been thoroughly taken up.

Chapter I -- Alcohols

A. Alcohol in General

It should be made clear that the term alcohol as used in chemistry does not refer merely to the compound found in intoxicating drinks, but also to a variety of liquids that contain carbon, hydrogen, and the OH radical. At least seventeen such liquids are known, but only the two most commonly used, namely, ethyl alcohol and methyl alcohol, should be considered.

B. Uses of Ethyl Alcohol

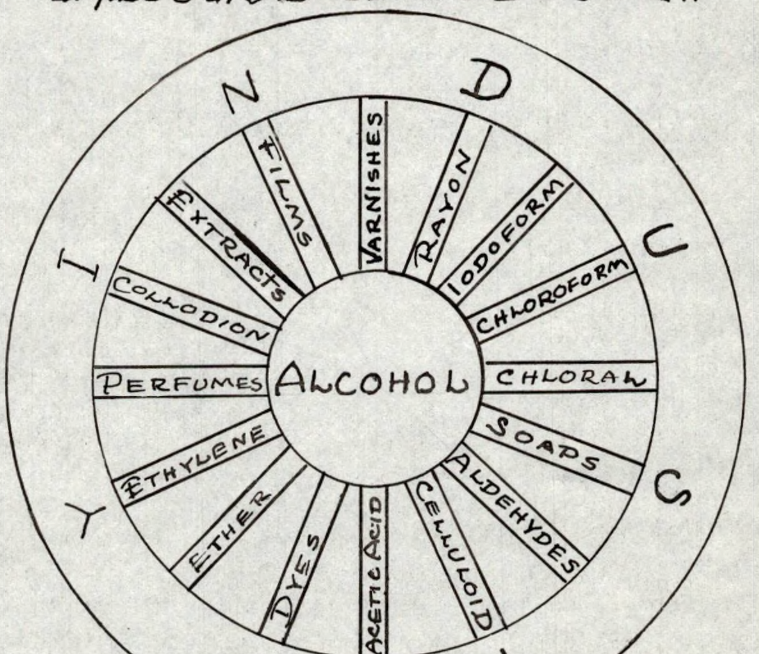
The direct and indirect uses of ethyl alcohol should be taken up. It should be emphasized that ethyl alcohol ranks very high among the important chemicals, being surpassed only by water, sulphuric acid and sodium chloride. For most industrial needs grain or ethyl alcohol is denatured by the addition of certain substances. This process prevents its use as a beverage and still permits its use for the purposes desired.

Under uses of ethyl alcohol to be considered should be the following: (1) as a solvent for many drugs and medicines, (2) to make antifreeze mixtures, (3) mixed with gasoline as a fuel for government airplanes, (4) in preparation of flavoring extracts, perfumes, hair tonics, tooth pastes, shaving creams, varnishes, shellacs and other products.

Under indirect uses are those in which ethyl alcohol is employed to prepare other compounds. Among the common chemicals and commercial products which require ethyl alcohol in their manufacture are ethylene, ether, chloroform, iodoform, vinegar, dyes, celluloid, artificial silk, artificial leather, explosives and motion picture films. Some of these products will be mentioned in the unit on cellulose products.

Diagram 3

Alcohol in Industry[1]



[1]Biddle and Bush, Dynamic Chemistry, p. 673.

Diagram 3 shows the importance of alcohol in industry.

The preparation of alcohol by using yeast and sugar should be taken up in the unit on foods.

C. Methyl Alcohol

Methyl alcohol should first be pointed out as a deadly poisonous alcohol. The uses of methyl alcohol should be taken up, including its use in denaturing ethyl alcohol, as a solvent in various industrial processes such as the manufacture of shellace, resins and dyes. It is also used in manufacturing formaldehyde.

The two sources of methyl alcohol should be considered, especially the synthetic method, because it is the commercial method of producing methyl alcohol.

D. Behavior of Alcohols as Bases

It should be made clear that the chemical behavior of any alcohol is primarily due to the behavior of the hydroxyl groups. They are, therefore, sometimes called organic bases.

Chapter II -- Organic Acids

Organic acids are similar to the inorganic acids in their chemical reactions. They are classified into two general groups, the fatty acids and the non-fatty acids.

A. Fatty Acids

The fatty acids are usually produced from vegetable fats and oils. The acids to be taken up should include first acetic acid because acetic acid forms the principal part of vinegar. Its preparation, properties and uses should be taken up.

Other fatty acids include formic, propionic, butyric, palmitic and stearic acids. Palmitic and stearic acids should receive special mention because they are produced from nearly all fats.

B. Non-fatty Acids

There are hundreds of non-fatty acids, but only a few need be discussed. Some of the more common ones are: (1) oxalic acid found in rhubarb, used in the home for removing ink and rust stains and commercially in printing calico and dyeing, (2) citric acid found in citrus fruits, (3) tartaric acid found in certain fruits and used in baking, (4) malic acid found in green apples, cherries, raspberries, strawberries, currants, grapes, pineapples and in many vegetables, (5) lactic acid found in sour milk and in our muscles as a result of exercise. (It is therefore called the acid of fatigue.)

Chapter III -- Fats and Oils as Esters

A. Formation of Esters

Both plants and animals form a number of substances which are classed as fats and oils. The plant products are usually liquids and are called oils, for example: olive oil and cottonseed oil. Similar substances made in the animal body from the vegetable oils it consumes are semi-solids and are called fats, such as butter and lard. All these substances may be broken down by heating with water and a catalyst, to yield a mixture of organic acids and an alcohol glycerol. A compound which can be hydrolyzed in this way is called as ester. The two most important acids which are found in fats are palmitic and stearic acid.

An example of a very simple ester is ethyl acetate. This ester should be prepared in the laboratory from ethyl alcohol and acetic acid so the student can see how easily an ester can be prepared. The simple esters of low molecular weight are low-boiling liquids of pleasant odor and are used in preparing lacquers. Lacquers are taken up under cellulose products in another unit.

Ethyl acetate is but one representative of the large number of esters that are prepared synthetically by the action of alcohols and organic acids,usually with the aid of sulphuric acid.

B. Uses of Esters

Synthetic esters are used in the manufacture of a number of flavoring extracts and perfumes. Some of the common ones include: rose, wintergreen, peppermint and banana oil.

C. Common Fats and Oils

Esters from fats and oils make up a very important class of foods. Some of the leading vegetable oils and fats are cottonseed oil, corn oil, olive oil, linseed oil, peanut oil, castor oil, and coconut oil.

The leading animal fats and oils are oleomargarine, butter, lard, suet, tallow, and codliver oil.

The leading esters from fats and oils are olein, palmatin and stearin. These are formed from glycerin, oleic, palmitic or stearic acid.

D. Changing Oils to Solid Fats

This would take up the process of hydrogenation of oils or semisolid fats. Experiments should be carried out to show how the process really takes place.

Chapter IV -- Soap

Greater quantities of vegetable and animal fats and oils are used in the manufacture of soaps than are used in any other way. The manufacture begins with the interaction of the vegetable or animal fats and oils with sodium hydroxide or potassium hydroxide. The process by which a vegetable or animal fat or oil unites with an alkali to produce soap and glycerine is known as saponification

A. Preparation of Soap

1. Laboratory Preparation

The best way to make soap making clear to the student is to make some soap in the laboratory. This can be done by dissolving 100 grams of sodium hydroxide in 200 grams of water and shaking this with an equal volume of denatured alcohol. Now in a large test tube put equal volumes of olive oil and the alcoholic sodium hydroxide. Shake while warming slowly. At first the liquids separate in two layers showing them to be immiscible. At a certain point there is a sudden frothing and disturbance in the mixture. When this reaction stops the liquid is clear and without separate layers. This product is soap, and the reaction is saponification. When cold water is run over the outside of the test tube the soap turns to a yellow solid.

2. Home Preparation

Because much soap is made in homes where there is a supply of meat grease, the method should be taken up here. Some of the important steps in making good soap at home should be explained.

3. Commercial Soap Factories

Commercial soap making should be explained. There are different processes used,namely, the boiled process and the cold process. In the boiled process the glycerine is salted out. This process should be carried out on a small sample of the soap already prepared in the laboratory. In the cold process the glycerine is left in the soap. The Twitchell process of making soap should also be explained. This process is important because it takes the glycerine out before saponifying.

B. Varieties of Soap

The student should become familiar with the following varieties:

1. Floating soap made by "crutching" into the soap enough air bubbles to render the solid mass less dense than water.
2. Transparent soap made by adding sugar and alcohol to the soap.
3. Castile soap originally cold-process soap made from pure olive oil. Today peanut oil, cottonseed oil and other oils are used. The glycerine remains in this soap.
4. Soft soap is usually made by using KOH instead of NaOH.

5. Liquid soaps are usually alcoholic solutions of soft soap.
6. Shaving soap is a white soap containing free stearic acid or some gum to render the lather more permanent.
7. Salt-water soap is made from coconut oil with either NaOH or KOH or a mixture of them.
8. Colored soaps and scented soaps have dyes or perfumes added to them. These additions do not increase the cleansing power. Even antiseptics such as are in the so-called "carbolic" soaps seldom are in concentrations sufficient to be effective. They are smelly but depend for their cleaning and disinfecting abilities upon the quality of the soap itself. "Tar" soaps and "dog" soaps may contain creosote or other germicides which aid the soap in disinfecting.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 673-695.
Brownlee and Others, First Principles of Chemistry, pp. 671-687.
Black and Conant, New Practical Chemistry, pp. 442-451, 463-466.
Gordon, Introductory Chemistry, pp. 468-476.
Horton, Modern Everyday Chemistry, pp. 368-372.
McPherson, Henderson, Fowler, Chemistry for Today, pp. 384-400.
Wilson, Descriptive Chemistry, pp. 234-239.

Unit 10

FOODS

Introduction

Although a study of foods is made in other science courses, a real understanding of foods, their digestion and means of preservation is impossible without a study of the chemistry of foods. A person must know the chemical composition of proteins, carbohydrates, fats, and minerals in order to understand how they are broken up by digestive processes and finally made use of by the body for various purposes.

More and more emphasis is being placed on the importance of vitamins as well as the knowledge of foods rich in the various classes of vitamins.

Not only is proper food necessary for good health, but the preservation of our foods is an important problem of health.

Bread making cannot be understood without an understanding of fermentation and the action of various baking powders, and all these reactions will become clear after becoming acquainted with the chemistry involved.

Chapter I -- Foods in General

A. Purposes of Food

The food we eat serves three distinct purposes: (1) to build up new parts and replace worn out ones, (2) to keep the body at the required temperature, (3) to supply the energy which enables us to work. Another purpose may be added, namely, body regulating other than for heat.

B. General Classification of Compounds in Foods

The compounds of foods are usually grouped into five large classes: fats, carbohydrates, proteins, minerals and water. Besides these five classes, foods also contain small quantities of substances known as vitamins.

C. Classification of Foods as to Function

1. Heat Producing

The heat producing foods include fats and carbohydrates. Under the study of fats should come the study of olein, sterine, palmitine, and linseed oil, unless studied in the unit before this. Under the study of carbohydrates should come a study of our sugars and starches. Under this study the student should be made to understand that heat producing foods aid in regulating body temperature, as well as producing energy in the form of heat to aid us in doing our work. Some of the foods that are chiefly heat producing should be mentioned.

2. Cell Producing

The cell producing foods are the proteins. These are rich in nitrogen, for instance lean meat and the white of eggs.

3. Body Regulating

They include minerals, vitamins, water and foods eaten only because they furnish bulk and so aid in regulating the body. Minerals are used largely in building bone tissue but have other uses not fully understood. Vitamins are necessary for proper growth and good health, but just how they accomplish this is not clearly known. Water helps to carry the digested foods to various parts of the body and to remove waste products as well as to aid in regulating body temperature. Bulk foods are eaten to help the digestive organs eliminate waste more effectively.

4. Vitamins

Vitamins were mentioned before as small quantities of substances which insure proper growth and aid in keeping the body well and in fighting off disease. They have been grouped into various classes according to the effects they produce upon the body.

The following table names the various classes, lists some of the foods which belong to each, and tells what happens when the foods are omitted in the diet.

Table 6

Classification of Vitamins[1]

Classification	Foods in Which Abundant	Results of Omission in Diet
A Anti-infective	butter, cream, cod-liver oil, carrots leafy vegetables	Infections of eye, ear, sinus, skin, lungs; cessation of growth
B (F-G) Anti-Neuritic	yeast, whole grain, green vegetables, tomatoes	Nerve diseases (neuritis); beri-beri, indigestion, constipation stunted growth, loss of weight
C Anti-scorbutic	oranges, other citrus fruits, tomatoes, green vegetables, fresh fruits	Scurvy, characterized by ulcerated gums & fleeting pains in joints & muscles; slow healing of wounds
D Anti-rachitic	codliver oil, egg yolks, butter, milk	Rickets & resulting poor development of bones & poor teeth
E Anti-sterility	most grains & green leafy vegetables	Sterility in males, resorption of developing young in females
F (B_2) Anti-neurotic	cereal grains, yeast	Beri-beri
G (B_2) Anti-pellagric	yeast, green vegetables, milk	Pellagra, loss of weight, weakness

After studying this table some experiments could be carried out on animals to show the necessity of certain vitamins in the diet.

[1] Biddle and Bush, Dynamic Chemistry, p. 726.

Chapter II -- Enzymes and Digestion

A. Enzymes and Digestion in General

The general purpose of enzymes in the body should be understood by the student. The story of digestion is largely the story of the work of enzymes. The student should become familiar in a general way with the three classes of enzymes according to the kind of work they do, namely, (1) the lipase group affecting fats, (2) the amylase group affecting carbohydrates, (3) the protease group affecting proteins. A general study should be made of the work of each of these groups in affecting the digestion of fats, carbohydrates and proteins.

Chapter III -- Preservation of Foods

In order that people may at all times have a well balanced variety of foods it is necessary that some of the foods be preserved. This means that certain steps must be taken to prevent the growth of bacteria so that the foods will not rot or decay. The most common methods of preservation are as follows: (1) drying, (2) placing in cold storage, (3) sterilization and sealing, (4) treating with chemical preservatives. Each of these methods of preserving food should be studied. Special emphasis should be placed on the use of electric refrigeration and dry ice, because the use of these methods is constantly increasing. A study should be made of some of the common chemical preservatives and adulterants used in foods.

Chapter IV -- Products of Fermentation

Fermentation found in foods deals with the action of yeast used in making of bread. The yeast acts on the starch or sugar solution to form carbon dioxide and ethyl alcohol. If the alcohol is acted upon further it is broken up first into acetaldehyde and finally into acetic acid or vinegar. Because similar fermentation takes place when some foods spoil, these various steps in fermentation with the various resulting products should be made clear.

Chapter V -- Baking Powders

After becoming familiar with the formation of carbon dioxide through fermentation, another way of forming carbon dioxide in cakes and bread by using baking powders should be studied. The action of sodium bicarbonate was taken up in Unit 6 but should be reviewed now. The carbonate should be treated with an acid such as tartaric acid, cream of tartar, alum or sodium diacid phosphate. The composition of the common baking powders bought on the market should be studied and the advantages of making your own baking powder pointed out.

<u>TEXTBOOK REFERENCES</u>

Biddle and Bush, <u>Dynamic Chemistry</u>, pp. 720-729.
Brownlee and Others, <u>First Principles of Chemistry</u>, pp. 691-695.
Black and Conant, <u>New Practical Chemistry</u>, pp. 453-458, 466-471.
Gordon, <u>Introductory Chemistry</u>, pp. 249-255.
Horton, <u>Modern Everyday Chemistry</u>, pp. 309-318, 340-363.
McPherson, Henderson, Fowler, <u>Chemistry for Today</u>, pp. 372-377, 406-414.
Wilson, <u>Descriptive Chemistry</u>, pp. 147-184.

Unit 11

CELLULOSE PRODUCTS

Introduction

Cellulose, which is the cell membrane of all plants, is the basis of many useful products. The number of products made from cellulose is steadily increasing, and the uses made of these products is also increasing. It was not so very many years ago that paper towels were unknown. Their widespread use at present is only an indication of the development of paper manufacturing technique. The use of rayon instead of real silk and mercerized cotton instead of ordinary cotton have similar histories. The recent widespread use of cellophane should become a source of interest for the entire study of cellulose products, but other interesting and useful products taken up in this unit will include gun cotton, artificial leather, lacquers, ducos, enamels, combs, and ornaments. A general knowledge of how these products are made will serve to make it possible for students to know more about their environment.

Chapter I -- General

Cellulose makes up the cell membranes of all plants. It provides the chief raw materials for the direct manufacture of many commercial products, the most valuable of which are paper, cotton cloth and linen. In addition it provides the chief raw materials for the manufacture of many useful products made indirectly through chemical changes.

Chapter II -- Cellulose Products

A. Paper

1. Importance of Paper and Source of Raw Materials.

So much paper is made that the manufacture of paper is considered one of the leading industries of the world. It is made from the fibers of wood, cotton, flax, straw, cornstalks, and various other plants.

2. Manufacture of Paper

The process of manufacturing paper should be studied in detail. The following steps would serve as an aid:

(a) The logs of spruce, hemlock, poplar, balsam, or pine trees are stripped of their bark and cut into short blocks.

(b) The blocks are then taken to a pulp mill, where they are shredded or ground into chips.

(c) The chips are made into a pulp by the separation of the cellulose fibers. This is accomplished in one of two ways, both of which should be studied.

(d) The pulp is washed and bleached in order to remove or decolorize the various undesirable impurities. The method of bleaching should be studied.

(e) The pulp is beaten, sized, dyed or otherwise treated to give the paper the particular qualities desired. The beating process, sizing process, and dyeing process should be taken up.

(f) The final step consists of making the pulp into sheets of paper by passing it through heavy steam-heated rollers.

3. Kinds of Paper

"Newsprint" paper, book paper, wrapping paper, writing paper, blotting, tissue, filter and parchment paper should be taken up to show the characteristic differences of each kind.

B. Cellulose Textiles

1. Mercerized Cotton

This process of treating cotton with sodium hydroxide solution to give a product with certain advantages over ordinary cotton is important. The process itself as well as the results should be studied.

2. Artificial Silk or Rayon

Although there are several methods of making rayon, the viscose method is used to make about 85% of the total product and therefore need be the only method stressed.

C. Additional Cellulose Products

1. Cellophane

Because of the increased use of this product, the student should know how it is made.

2. Cellulose nitrates or nitro cellulose

(a) Guncotton--This product is made from cellulose treated with a mixture of nitric and sulphuric acids and makes a powerful explosive. It is used in turn to make smokeless powder.

(b) Pyroxylin--This is a term used for certain soluble cellulose nitrates. Pyroxylin is used as a substitute for leather. Solutions of pyroxylin are used to make rapid-drying lacquers, duco, fingernail enamels, ornaments, combs, etc.

(c) Collodian and Celluloid--These are prepared from a solution of pyroxylin in alcohol and ether. Collodian is used to cover small cuts and wounds on the skin. In industry it is used as an ingredient in celluloid photographic films.

(d) Cellulose Acetate--This product is taking the place of nitro cellulose for making "safety" motion picture films.

3. Explosives

(a) Because glycerol was mentioned in connection with soap making it need only be mentioned here as to the part it plays in making dynamite and T. N. T.

(b) Black gunpowder may be prepared by the students as an experiment by using potassium nitrate, sulphur and charcoal. This will have to be ignited. An explanation should be made of high explosives to show how they burst into gases without burning. This is called detonating, and the use of a "detonator" should be explained.

(c) Explosives in War and Peace--The uses of explosives in industry during peace time should be pointed out. Too much emphasis is placed on the use of explosives during war. The use of explosives for clearing away obstructions, making excavations, tunneling, etc., cannot be over emphasized. An example of the value of explosives to civilization can be brought in.The Romans required 30,000 men working for eleven years to tunnel three miles; today with high explosives and machinery the same work could be done in ten months by 100 men.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 321-333, 712-719.
Gordon, Introductory Chemistry, pp. 479-484.
Horton, Modern Everyday Chemistry, pp. 323-332.
McPherson, Henderson, Fowler, Chemistry for Today, pp. 378-383.
Wilson, Descriptive Chemistry, pp. 124-129.

Unit 12

TEXTILES AND DYES

Introduction

Everyone knows there is a difference between the four common fibers, but besides knowing that two of them are plant products and two animal products, usually nothing further is known. When the chemist decomposes each of these four fibers and performs certain tests upon them, their composition becomes known and new interest is gained about them.

When people buy clothing they are ordinarily at the complete mercy of the sales person, but if a knowledge of textile chemistry was applied, the buyer could buy with full confidence that he was getting full value for his money. This is an example of the application of practical chemistry as an aid to an individual.

Often people do not realize the reason for the difference in the cost of various kinds of cloth, because they do not know anything about the processes of making the different fabrics.

The topic of dyes and the dyeing of fabrics is an interesting one, and a general understanding of the principles of dyes and dyeing should prove useful to all individuals.

Chapter I -- Tests of the Four Common Fibers

A. Composition of Fibers

By means of heating samples of cotton, linen, silk and wool in dry test tubes and testing with moistened litmus paper and lead acetate paper some conclusions can be drawn. From these conclusions the students will decide that cotton and linen are made up of carbon, hydrogen and oxygen, or they are cellulose products, while wool and silk are proteins, silk containing nitrogen in addition to the other three elements, and wool containing nitrogen and sulphur in addition.

B. Source

The source of the four fibers need not receive much attention except to classify them into two classes, animal and vegetable products.

C. Other Tests

1. The burning test should be repeated, this time to note the odor from the animal fibers in contrast to that of the vegetable fibers.
2. The nitric acid test could be performed to further show the difference between the animal and vegetable fibers.
3. The microscope test should be used to show the difference between each of the four fibers.

4. The behavior of the four fibers with dilute hydrochloric or sulphuric acid should be noted. The results will show that cotton and linen must not be exposed to the action of acids in laundering, bleaching or dyeing. This also serves as a way of separating wool from cotton and is used to reclaim wool from wool and cotton mixtures. This process should be explained as it is used quite extensively.

5. The alkali test is very important to show how caustic soda or potash dissolves wool and silk but has no visible effect upon cotton or linen. This test can be used to test goods to find out if they are mixtures of cotton and wool. An experiment to test goods which are cotton and wool mixtures to find out the per cent of wool should be carried out in the laboratory.

Chapter II -- Making Fabrics

A. General

The three common ways of making textile goods are: (1) weaving, (2) knitting, and (3) felting. The main differences of these three methods should be noted.

1. Making Wool Cloth

This would include a study of shearing the wool from the sheep, washing, combing, carding (in some cases), spinning, weaving, and knitting. The different reasons for each of these processes should be pointed out and the difference in the products obtained.

2. Making Cotton Cloth

The preparation of cotton cloth requires the following steps: (1) picking, (2) ginning, (3) carding, (4) spinning, (5) weaving, (6) bleaching, (7) dyeing.

Because most of these steps are mentioned in the study on the making of wool cloth they need not be studied now. The bleaching process is a chemical process and an important one. The steps can be carried out in the laboratory to show the effects on a piece of cotton cloth.

3. The Silk Industry

The study of the silk industry should include a study of how the silkworms are bred artificially and then how the silk is obtained from the cocoons. Because so much of our silk is weighted, a study should be made of what weighted silk is, how it is made, and how it can be detected.

Chapter III -- Dyes and Dyeing

A. What Are Dyes

Dyes are such complicated chemical compounds that only a general explanation of dyes should be made.

It should be emphasized that dyes used to be made from vegetable and animal extracts but are now mostly products of the chemical laboratory and are called synthetic dyes. An explanation should also be made as to the different ways dyes are sold and the chemist's way of classifying dyes.

B. Conditions Favorable to Dyeing

The general conditions favorable to dyeing are soft water, sufficient liquid to cover the goods, uniform spreading of the dye through the bath, possibility of stirring or moving the goods to expose all parts equally.

Besides these conditions the following three conditions should be brought out by an experiment.

1. Hot or cold bath?
2. Concentrated or dilute bath?
3. One or five minutes' time in the bath?

The conclusions that should be arrived at from this experiment are that the depth of color in goods is increased (1) by greater concentration of the dye bath, (2) by higher temperatures, and (3) by longer time in the bath.

C. Generalization

Because all dyes do not affect the four types of fibers alike some knowledge of the effect of mordant dyes, lakes, acid and basic dyes on these fibers should be understood. An explanation of why colors run or bleed should be made. The problem of home dyeing is mostly being able to follow the directions. The problem of fast colors means making the colors fast to light, water, perspiration, soap, and air. Because the theories of dyeing are not clearly understood even by the chemists it should not be studied further here.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 499-512.
Emery and Others, Chemistry in Everyday Life, pp. 488-511.
Black and Conant, New Practical Chemistry, pp.458-462, 560-566.
Horton, Modern Everyday Chemistry, pp. 392-410.
Wilson, Descriptive Chemistry, pp. 224-232.

Unit 13

CLEANING, SANITATION, AND WASTE DISPOSAL

Introduction

Too little importance has been placed on the subject of cleaning, sanitation, and waste disposal, but public opinion is becoming aroused to its importance, and consequently, it is gaining in prominence. The more people begin to realize its importance, the more they want to know about it. In order to understand the subject, chemistry must enter in.

Too often people buy disinfectants or germicides without knowing anything about them or without understanding what results should be expected. Many painful and often serious results have occurred when the wrong chemical was used or a known chemical was used at the wrong time. These results are often brought on through ignorance of the chemistry of the substance or of its reaction.

Soap is still used more extensively than any other material for cleaning and sanitation. Many interesting things can be learned about soap, including how it cleans and how it reacts with hard water.

Dry cleaning, both commercially and in the home, is interesting, but the proper methods to use in dry cleaning at home should be stressed. There are many fatal accidents caused because people do not know the safe and sane methods to be used.

Proper sewage and waste disposal are of such extreme importance to our health that an understanding of the more important principles should be understood in order to properly safeguard the community, farm, and home.

Chapter I -- Cleaning and Sanitation

A. General

First should come a clear understanding of the meaning of cleaning in terms of chemistry. The student should be made to understand that the purpose of cleaning is primarily for the sake of our health, not just to make dirt invisible. Cleaning in terms of chemistry means the use of agents which disinfect as well as remove spots, stains, or visible dirt.

B. Disinfection

1. Meaning of Disinfection

When a person gets an infection, germs have entered the body. A disinfectant is a germicide or a poison for germs. The purpose of disinfectants is to destroy or remove the cause of infection. The germicides used for personal hygiene also are disinfectants, but many disinfectants would be unsuitable for use in or on the body.

2. Types

(a) Soapsuds--The advantages and uses of soap as a cleaning agent and disinfectant should be stated.

(b) Creosote--This disinfectant is used with soap as a disinfectant because it is a powerful germicide. The various uses of creosote should be mentioned as well as the fact that creosote is sold under various trade names.

(c) Chloride of Lime--Its composition and uses as a deodorant and disinfectant should be studied.

(d) Household Ammonia--Ammonia has been studied in Unit 2 but should be mentioned again because of its wide use as a grease remover and mild disinfectant.

(e) Kerosene and Gasoline--These materials are not used very extensively as a disinfectant but have some use in destroying bedbugs and their eggs.

(f) Sulphur Dioxide, formed usually by burning sulphur, has many uses, all of which should be mentioned.

(g) Hydrocyanic acid gas should be mentioned as a poisonous gas used only when a house is unoccupied and then only under supervision of trained exterminators.

(h) Formaldehyde is used either in solution or as a vapor. Its uses should be mentioned.

(i) Lye is a compound that has already been mentioned, but its use as a powerful solvent for grease should be emphasized.

(j) The uses of other disinfectants should be pointed out, such as sodium fluoride, carbon bisulphide and various moth preventatives.

C. Dry Cleaning

1. Experiment with volatile grease solvent

A simple yet clear way of showing the principle in dry cleaning can be carried out by taking a piece of white cloth and putting on it a spot formed of cottonseed oil and bone black. This cloth is then put in a test tube with carbon tetrachloride and shaken a few minutes. After being removed and dried, the cloth will show no trace of oil or black color. The principle demonstrated is that the oil dissolved in the carbon tetrachloride. This loosened the dirt which was washed off.

2. Commercial Dry Cleaning

A study should be made of the most important principles and practices of commercial dry cleaning. The more common volatile grease solvents used should be mentioned.

3. Dry Cleaning at Home

A study of this type of cleaning should be made primarily to acquaint the student with the safe and sane methods that can be used in the home.

The dangers of dry cleaning at home with inflammable and explosive grease solvents cannot be overemphasized.

4. Removing Spots and Stains

The students should not make any attempt to become familiar with the various ways of removing different spots and stains. This requires trained experts, and no one should be encourage to do much of this kind of work at home, especially on valuable garments.

Chapter II -- How Soap Cleans

Soap was mentioned as a cleaning agent and disinfectant in Chapter I, but it is used so extensively to remove dirt that its preparation is discussed in detail in a different chapter.

A. Why Does Soap Clean?

By means of simple laboratory experiments the action of soap on mixtures of dirt and grease of various kinds can be clearly demonstrated. After the demonstrations explanations should be made.

B. Soap in Hard Water

Because so many natural waters are hard the question naturally comes up as to what to do with hard water when it is to be used for cleaning or laundry purposes. In this connection artificial hard water should be made and its behavior with soap clearly demonstrated. The difference between temporary hard and permanent hard water should be demonstrated and explained. This chapter should be concluded with a study of the different home and commercial ways of softening hard waters.

Chapter III -- Waste Disposal

A. General Problems of Waste

The disposal of waste from the aspect of sanitation in the home or community is of great importance. The problem should be presented from the point of view of the private home, farm and community. In large communities muck and waste from factories present an additional problem.

B. Sewers, Cesspools, and Septic Tanks

These means of disposing of waste should be studied separately from the point of view of type of construction, economy of construction and efficiency. Each individual in every community should know the difference between each of these three types of waste disposals so they can intelligently decide for themselves and the community which method is best.

C. Disposal of Garbage

People are beginning to see the need of a more intelligent means of disposing of garbage than formerly. The student should become acquainted with the newer ways of taking care of garbage, especially table garbage. This would take up a study of incinerators and retorts.

D. Other Waste Problems

This would include a study of properly disposing of paper, manure from stables, factory wastes and smoke with newest methods being used in taking care of each problem.

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Unit 14

HOW MAN FIGHTS HIS COMMON ENEMIES

Introduction

An agricultural nation is becoming more and more dependent upon chemistry to aid it in its fight against various plant enemies. No other science can be used to combat the plant diseases and insect pests that are constantly threatening to destroy our plant life. A great deal of information is necessary in order to properly take care of the plant enemies, because every enemy requires a different method of procedure to check its growth and prevent it from being destructive.

In the study of sanitation one becomes familiar with antiseptics and disinfectants, but the terms are used again here in man's fight against plant enemies, and in addition, insecticides and fungicides also become familiar terms. Man cannot continue to secure his livelihood from the soil unless he lets chemistry aid him in protecting himself against the constantly increasing numbers of plant enemies.

Chapter I -- Plant Enemies and Their Control

A. The Problem

1. One of the greatest problems of the farmer is the control of insect pests. Often if he does not

fight the pests, they harvest his crop long before it even ripens. He must spray his fruit trees, apply poisons to many of his vegetables, and must take steps to protect the crops he grows in his fields. Chief among the grain enemies are the Hessian fly, the corn barer, the earworm, the army worm, the cut worm, and the grasshopper. In the South the cotton farmer has to fight the boll weevil.

2. Searching for Perfect Sprays

The same poisons do not affect all insects alike. A poison that kills one insect may have little or no effect on another. Much depends on the habits of the insect. If it chews the leaves or bark of plants it may be killed by a poison sprayed on the leaves or bark. On the other hand, if an insect sucks juices from the inside of plants, it must be smothered by a poison that clogs the air tubes through which it breathes. One problem in spraying is to secure a poison that will not be washed away by rains. Another is to secure a poison that is harmless to people or animals when they eat the plants on which it has been used.

B. Types of Plant Enemies

Insects, rusts, molds, mildews and other parasites try to get their living by feeding from man's gardens and orchards. By the use of insect poisons (insecticides) or fungus killers (fungicides), chemistry tries to control these enemies, but in order to use these poisons the grower of plants must know the life histories of the parasites and their feeding habits. He must also know something about the effects of chemicals and the making of solutions or emulsions.

C. Types of Poisons

1. Bordeaux mixture made from milk of lime and copper sulphate is sprayed on all kinds of plants to control fungus diseases.
2. Arsenate of lead (or of calcium) is used in sprays to kill most insects which chew leaves or prey upon fruit.
3. Nicotine is sprayed on small plants to control juice sucking insects.
4. Lime-sulphur mixture, either dry or in liquid form, is used also to control fungus. This is often used with Bordeaux mixture or with arsenate of lead for a general spray.
5. Formaldehyde is used to spray on seeds to prevent smut. It is also used to treat potato seed to prevent "scab" fungus.
6. Hydrocyanic acid and its principal salts, sodium cyanide and potassium cyanide, are among

the most poisonous substances known. Prussic acid or hydrocyanic acid is used largely to kill insects on plants in greenhouses or on fruit trees.

7. Pyrethrum is a poison made from plants which has been known for some time. It has been used successfully in China and Japan, but only recently has it been used in the United States. It promises to become one of the leading poisons for the destruction of insects.

8. Sulphur compounds are being experimented with because these compounds have the advantage of being harmless to human beings and farm animals and easy to produce.

Chapter II -- Disinfectants and antiseptics

A. Definition

An antiseptic is a substance used to prevent the growth of bacteria. A disinfectant is a substance that kills bacteria already at work. These substances serve different purposes, and the student should learn these purposes so as not to confuse these terms.

B. Common Types and Their Uses

1. Mercuric Chloride

This is a white solid compound used as an antiseptic in surgery and in dressing ordinary cuts and wounds. The student should be warned that it is extremely poisonous if taken internally.

2. Lysol and Listerine are common household disinfectants and antiseptics.

3. Other disinfectants and antiseptics with which the student should become familiar include the following: alcohol (ethyl), argyrol, boric acid, Dakins' solution, formaldehyde, iodine, iodoform, mercurochrome, mercury (ammoniated), phenol, picric acid, potassium permanganate, silver nitrate and zinc oxide.

TEXTBOOK REFERENCES

Biddle and Bush, Dynamic Chemistry, pp. 732-733, 767-770.
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Unit 15

METALS

Introduction

It has been said for some time that man is living in a metal age. It is becoming more and more true. Ever since man learned the principle of metallurgy, or how to extract the metals from their native state in the ground, metals became more necessary to man's existence.

Not only is the study of how metals are purified from the impure state important, but perhaps of greater importance is the study of how metals are combined with each other in varying amounts or proportions to form alloys. An article made of an alloy is often taken to mean something inferior to an article made of the pure metal. Only after learning the chemistry of metals and alloys does one really understand the place each takes in the present metal age.

Chapter I -- Principles of Metallurgy and Ores

The important metals are found as compounds containing sulphur, oxygen, and silicon. Many compounds of the metals which occur naturally as minerals are not suitable for use in the preparation of the free metals. In general, the oxides, sulphides and carbonates, when mined in a comparatively pure condition, are the most suitable starting points. Such substances are called ores, and the science that deals with the extraction of metals from their ores is called metallurgy.

The methods of obtaining metals from their compounds may be classified as follows: (1) electrolysis of the fused salts as in the preparation of sodium, calcium, and aluminum, (2) reduction of the oxide or sulphide in a furnace. The advantages of each of these two general methods should be made clear.

Chapter II -- Metallurgy of Iron

A. Preparing Iron from Iron Oxide

In order to make the purifying of iron ore clear to the student a simple experiment should be carried out. Iron should be prepared from iron oxide by passing hydrogen over heated ferric oxide. The product formed after being cooled should be tested with a magnet and also with hydrochloric acid to prove that it is iron. Additional experiments may be carried out, such as heating a mixture of charcoal powder with some iron oxide to produce iron and carbon dioxide or iron oxide and ordinary water gas wherein the iron oxide reacts with the carbon monoxide to produce iron and carbon dioxide.

B. Blast Furnace

The structure and operation of a blast furnace should be studied. The student should become familiar with the "charge" used and the chemical reactions involved.

The use of the "stoves" used in connection with the blast furnace is important because it shows the economy of the operation of the blast furnace.

C. Products of the Blast Furnace

The importance of the slag and pig iron should be studied. Slag is useful for two reasons, first because it floats on top of iron and protects the iron from being oxidized again and then because it is used after being extracted from the blast furnace. Pig iron is important because it serves as the basis of all other iron. It is sometimes called cast iron, and from it all other forms of iron and steel are made. The composition and use of cast iron should be taken up.

D. Steel and Wrought Iron

The problem of making steel is to get rid of the impurities in cast iron and to add chemicals which will give the desired hardness and elasticity. To aid the student in understanding the chemical reaction in making steel, the Bessemer process must be studied as well as the open-hearth process and the crucible steel process.

After these processes have been taken up, the properties of steel should be studied. This will naturally lead to a study of tempering of steel. An explanation of hardness and tempering of steel should be made.

A study should be made of alloy steels made by the addition of certain elements in small quantities.

Because a certain amount of cast iron is made into wrought iron or malleable iron the reverberatory furnace which is similar to the open hearth furnace should be studied here in connection with the making of malleable iron.

Chapter III -- Metallurgy of Common Well-Known Metals

A. Metallurgy of Copper

A study of the process of refining copper would include the following steps: (1) removal of a portion of sulphur by roasting, (2) removal of the earthy material and the production of a complex matter, (3) production of impure copper known as blister copper from the matter, (4) partial purification of the copper by a process known as poling, (5) refining by electrolysis. This should be followed by a study of the uses of copper.

B. Metallurgy of Lead

The method of extraction of lead from its ore depends largely upon the purity of the ore, but the two processes should be discussed, namely, the use of a reverberatory furnace for ores having a large percentage of lead and a blast furnace similar to that used for copper for ore poor in lead. The uses of lead are quite extensive and should become familiar to the student.

C. Metallurgy of Zinc

Because zinc is found usually as an oxide or as a sulphide, the two methods of purifying zinc from these common ores are the only important processes. After studying the purifying processes, the properties and uses of zinc should follow.

D. Metallurgy of Aluminum

Because aluminum is coming into more common use every day the student should become familiar with the purification process used for aluminum. Because the electrolysis method made aluminum cheap enough for commercial usage it should receive fitting emphasis.

The properties and uses of aluminum should be taken up in detail, especially the uses made of aluminum in the pure state as well as its use in making alloys. The use of aluminum in the thermit process is of great importance and should receive proper emphasis.

E. Metallurgy of Tin

Tin is one of our common metals and was used in early history more than iron or steel. Because tin occurs mostly as the oxide it is very easily reduced by carbon, but often the oxide of tin is mixed with impurities in the ore which complicate the process. The common procedure then is to crush the ore, wash it free of earth materials and roast it to remove the arsenic and sulphur before reducing it with carbon in the form of coal.

The recovery of waste tin is important enough to receive consideration. Tin is reclaimed from two sources, (1) various waste tin alloys, and (2) the waste trimmings that accumulate in the manufacture of tin cans and other tin-plate products.

The properties and uses of tin should be emphasized. Under uses of tin should be studied: making tin plate, weighting silk, pure tin pipes and tin alloys, such as solder, babbit metal and type metal.

F. Metallurgy of Silver, Gold and Platinum

Because these are our precious metals and their purification is carried out by somewhat similar processes they could be taken up together, but because the metallurgy processes are complex, not much emphasis need be placed on it but more importance placed on the uses of these metals.

G. Metallurgy of Mercury

Mercury is usually found in the form of the sulphide and is purified by roasting when metallic mercury and sulphur dioxide is obtained. The metallic mercury is further purified by redistillation.

Some of the uses of mercury have already been studied, namely, using mercury in extracting gold and silver from their ores and the use of mercury in medicine as bichloride of mercury, mercuric chloride and calomel. Other uses should be taken up, namely, using mercury in thermometers and rheostats, in neon lamps, mercury vapor lamps, vapor engines and turbines as well as in amalgams of silver for filling teeth. Another important use of mercury is in manufacturing caps for setting off explosives.

Chapter IV -- Less Common but Valuable Metals

A. Manganese

Manganese is usually prepared by reduction of the ore pyrolusite or manganese oxide with powdered aluminum. This is known as the Goldschmidt process. It is also prepared by the electrolysis of its salts.

The uses of manganese are important enough to receive consideration in studying this metal. The uses that should be studied are: (1) the manufacture of steel, especially Bessemer steel as an alloy with iron, (2) the use of manganese dioxide as an oxidizing agent and in the manufacture of dry cells, (3) the use of potassium permanganate as an oxidizing agent in the laboratory and in medicine.

B. Chromium

Chromium is prepared in the same way as manganese and therefore no special study need be made of that.

The uses of chromium are important. The uses to be studied should include the plating of various articles with chromium and its use in producing chromium-steel alloy. The three properties of these alloys to resist corrosion, wear and heat should be emphasized. Another important use of chromium is the use of its compounds. One series of chromium compounds is used in tanning leather and as a mordant in dyeing. Another series of its compounds is used as pigments in paints and as oxidizing agents in tanning and dyeing and in many other chemical reactions requiring strong oxidizing agents.

C. Nickel

Nickel is most often found as a sulphide mixed with sulphides of other metals. Therefore, the extraction of nickel is a complicated process, resembling that used in obtaining copper. This process need not be studied in detail. The uses of nickel that should be taken up would include the following: (1) pure nickel in making coins and in nickel plating, (2) nickel in the manufacture of tough, strong, and corrosion-resisting steel alloys, (3) nickel and chromium in an alloy called nichrome, (4) a nickel alloy growing in use known as monel metal.

D. Cobalt

Cobalt is extracted by a process similar to that used for extracting nickel.

The uses of cobalt are similar to nickel. It is used in alloys of steel, especially for lathe tools. An alloy of cobalt, chromium and tungston called stellite has been used for the same purpose, but a new alloy of cobalt and tungston carbide called carboloy is now taking its place. This alloy is almost as hard as the diamond cobalt. Compounds are used to color glass and china and as a pigment.

E. Vanadium

Pure vanadium is seldom used and, therefore, is seldom prepared. It is, therefore, prepared as ferro-vanadium, a mixture of iron and vanadium. The processes employed are more or less trade secrets. The chief use of vanadium is in making vanadium steel, an alloy whose importance cannot be overemphasized. The compounds of vanadium are very numerous and are used principally in making aniline black, a substance used in dyeing and printing, in photography and as a catalyst. Vanadium is also used with platinum in the contact process of manufacturing sulphuric acid.

F. Tungsten

The extraction of tungsten is too complicated to be studied here. The uses of tungsten to be taken up should include: (1) making the filaments of electric light bulbs, because of its high melting point, (2) contact points in electrical equipment, (3) tungsten-steel alloy for high speed cutting tools.

G. Molybdenum

The use of this metal is growing in importance. It is used in manufacturing steel alloys, especially those used in airplanes and automobiles. It is also used extenisvely in the radio industry. Molybdenum compounds are used in coloring glazes on pottery and in dyeing wool, silk, and leather.

H. Titanium

The supply of titanium is very abundant, being more abundant than carbon or sulphur.

Compounds of titanium are used extensively in the manufacture of paints. Another compound is used in the steel industry to remove the air bubbles and also added to steel to make it very tough and able to withstand considerable wear.

I. Other Less Important Metals

A brief study of the metals palladium, uranium, cerium and thorium should be made because they have important uses.

Chapter V -- Chemical Use of Light

The purpose of this study should be to learn the principles of photography and the photo-electric eye. Many interesting experiments can be carried out in the laboratory to bring out some of the basic principles of light in chemistry and how it affects our daily lives.

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Gordon, Introductory Chemistry, pp. 257-304, 428-433, 503-569.
Horton, Modern Everyday Chemistry, pp. 154-166, 418-427.
McPherson, Henderson, Fowler, Chemistry for Today, pp. 415-439, 452-475, 482-546.
Wilson, Descriptive Chemistry, pp. 281-300.

Unit 16

CHEMISTRY OF BUILDING MATERIALS

Introduction

Often so much emphasis is placed on the importance of metals that not enough importance is given to the various other materials essential to man as building materials. Only after studying the chemistry of building materials can one understand the reason for water and lime mixed together and put on walls, forming a hard material, called plaster, after being exposed to air.

A person may suffer a broken leg but may have no explanation for what takes place when a cast is made and the cast "sets" into what is usually called a plaster of Paris cast. The making and setting of mortar and cement remain unexplained to anyone that does not permit chemistry to explain the reactions involved.

Ceramics and glass making are rapidly becoming arts of growing importance. Neither one of these arts would be possible without a chemist's thorough understanding of the composition of the materials used and of their reactions with certain materials under certain conditions.

Chapter I -- Limestone, Lime, and Mortar

A. Manufacture of Lime

Under this study would come the manufacture of quicklime or calcium oxide from the decomposition of calcium carbonate. A study should be made of the lime kilns, especially the rotary lime kilns.

B. Properties and Uses of Calcium Oxide

Its outstanding properties include its ability to react with water to form calcium hydroxide. This in turn reacts with carbon dioxide of the air to form calcium carbonate.

The most important use is to make slaked lime. Large quantities are used in making calcium carbide, in various chemical manufactures, and in dehydrating alcohol.

C. Properties and Uses of Calcium Hydroxide or Slaked Lime

Under properties should be included how it forms limewater or milk of lime when dissolved in water, also how it can be heated, causing it to lose water and again convert it into the oxide.

Because the water solution of calcium hydroxide is strongly basic, it has led to the wide use of the hydroxide as the cheapest base. In this respect, lime stands among the bases as sulphuric acid does among the acids.

In addition, other uses of the hydroxide should be emphasized, such as: (1) removal of hair from hides, (2) in paper making, (3) in agriculture, (4) treatment of sewage, and (5) as a whitewash. Some of these uses have been mentioned in other units but could be reviewed here.

D. Mortar

The formation of mortar, its properties and uses should be taken up in detail.

Chapter II -- Gypsum and Cement

A. Plaster of Paris

The formation of plaster of Paris from calcium sulphate or gypsum should be taken up in detail. Then the formation of plaster casts by adding water to the plaster of Paris is important. These two reactions should be studied thoroughly. The use of equations must be made in order to make the reactions understood.

B. The Making of Cement

Cement should be studied by starting out with the two raw materials ordinarily used. It should be mentioned that these raw materials are often found in natural cement rocks. Then the process of making Portland cement should be studied along with a study of the rotary kiln. The rotary kiln was considered in this unit under the manufacture of lime.

The reaction of cement in the hardening process should be taken up and explained thoroughly. This would lead to the use of cement in making ordinary concrete and reinforced concrete.

Chapter III -- Ceramics

A. Brick and Tile

The manufacture of brick and tile should be taken up with attention given to the different types of brick due to the different processes in manufacture rather than to difference in materials used.

B. Pottery, Earthenware, and Porcelain

Under this study would come first the materials selected for pottery making, earthenware and porcelain. Then would follow a study of how these articles are molded and shaped, then fired, glazed and finally colored.

Chapter IV -- Glass

A. How Glass Is Made

The composition of common glass should be studied first. It should be explained that glass is a mixture and not a definite compound. The operation of a glass furnace should be studied. The different ways of shaping glass should be studied, including molding, pressing, and blowing. The process of annealing and its importance should be fully emphasized.

B. Kinds of Glass

The student should become acquainted with the difference between common window glass, plate glass, crown glass, shatter-proof glass, cut glass or optical glass, and pyrex glass.

TEXTBOOK REFERENCES

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CHAPTER 3

CONCLUSION

The subject to be taught in chemistry should be selected on the basis of the actual needs of the pupils. Actual needs of the pupils would include both immediate and future needs.

The aims of secondary education, and especially of chemistry, should be important factors affecting the selection of what should be taught. After the important principles, facts, laws, hypotheses, etc., have been selected, all additional information and illustrative material should, as far as possible, be taken from the environment of the pupils.

J. O. Frank in his book, _The Teaching of High School Chemistry,_[1] has divided our high-school chemistry into three levels of subject matter: the _minimum essentials_ which will be taught wherever chemistry is found; the _local essentials_ which will vary with the nature of the community, and the _near essentials_ which will vary according to the class, the time that can be devoted to the course, and the general conditions that affect the strength or weakness of the course. If this plan of arranging the subject matter is used, it should be clearly understood that each unit of subject matter should con-

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[1] J. O. Frank, _The Teaching of High School Chemistry_, p. 56.

tain the three types, and each should be designated clearly so the pupil would know the relative importance of each item in the course.

The best sequence of units and the best organization of each unit are matters not entirely agreed upon yet, but there is one fact that is certain, and that is that the subject matter must be arranged in accordance with the psychology of the learning process. This would require that the subject matter would be arranged in the order of increasing difficulty. The time and attention placed upon each unit and each subdivision of each unit would have to be determined by its importance and by its place in the general scheme of arranging the subject matter.

One factor which affects the selection of the subject matter taught as much as anything else is the preparation of the teacher. No matter what course of study is being followed or what text book is being used, the teacher will give the most attention and emphasis to that which he knows best.

At the present time very few teachers of chemistry are teaching subject matter that has been selected and organized on the basis of the actual needs of the pupils. Most often the teacher selects a text and then proceeds to attempt to teach everything in that chemistry text. If the students can pass a satisfactory examination upon the material which has been covered, the teacher considers he or she has done a satisfactory job of teaching. This is not a check on whether there has been good teaching or not. It is not an indication that the subject has been taught with the new objectives and aims of secondary education constantly in mind.

The various accrediting agencies, such as the New York Board of Regents, The College Examination Board, The State Departments of Public Instruction, and The North Central Association of Colleges and Secondary Schools have made attempts to establish a standard body of subject matter for schools of various classes, but none of these has been able to lay out the best course for any particular school. The biggest beneficial work they have done has been to establish higher standards throughout, but all these agencies together have not been able to develop an entirely satisfactory program for science in our secondary schools.

Many changes in world affairs in the past few years have changed the ideas of what the aims in science education should be. Enormous strides in discovery and invention have produced situations that make it necessary for an average person to have a much more thorough understanding of the fundamental principles of science. A person cannot farm, operate an automobile, or run a modern home or do many other things which all are called upon to do every day, without some understanding of the scientific principles involved. These same scientific principles were not necessary to know twenty or thirty years ago. It, therefore, becomes necessary for chemistry teachers to teach the pupils so that they may be able to recognize all applications of chemical principles with which they come into contact, and be able to apply these principles in the solution of all problems of everyday life whenever these principles are applicable.

The startling facts brought out by the physical imperfections of the men drafted into military service during the World War showed that the physical health of the average person in the United States was far from what it should have been, considering the knowledge of the principles of sanitation and hygiene possessed by the people. This brings up the necessity of giving additional emphasis upon the health objective in science teaching. Chemistry should do as much, if not more, than any other science toward this health objective.

New discoveries made in preventive medicines, advances in the knowledge of sanitation, and in other phases of science have indicated the necessity of changes in the direction of efforts to bring the public to an understanding necessary to induce in them a willingness to take advantage of these advancements. Nothing but a better knowledge of science on the part of the average person will make it possible for the public to take advantage of the benefits of the various scientific discoveries and advances.

Some criticism has been made because it has been shown that most of the chemistry of the high-school courses is given again in college chemistry and that all laboratory work of high-school chemistry is repeated in college, but if this overlapping is a problem, then it should be a problem to be solved by the makers of college curriculums. The materials for the high-school chemistry course ought to be selected just as they would be if it were known that the subject were the last science the pupils would ever study.[2]

Questions asked of high-school graduates entering college seem to show that many of the most important facts of life and of the physical environment are not understood.[3] It is claimed that this is because high-school science is taught without recognizing the generalizations except in the science classroom.

Many college teachers have made the statement that high-school chemistry is of little advantage to those who take the subject in college. Some teachers claim that high-school science is an actual disadvantage, while others

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[2] J. O. Frank, The Teaching of High School Chemistry, p. 23.

[3] Ibid., p. 17.

believe that high-school work in the sciences is really valuable but that pupils fail to use their advantage when they take the same science in college. High-school chemistry is said to give only initial advantage to the student in college chemistry.[4]

An analysis of the objectives listed in nineteen courses of study in chemistry made by the National Survey of Secondary Education[5] indicates the following: only seven included the objective, "To acquire knowledge which will produce a better understanding of our environment;" only five included the objective, "To acquire knowledge of the application of principles in industry;" and under the objective, "To acquire knowledge which will function to secure the objective stated in the bulletin on Cardinal Principles of Secondary Education;" the health objective was found in only five, citizenship in three, worthy home membership in five, vocation in three, development of ethical character one, and worthy use of leisure in none. There were other objectives listed, but this gives one a very good idea to what extent the objectives listed in the courses of study fail to emphasize the practical side of a high-school chemistry course. Another interesting point

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[4]J. O. Frank, The Teaching of High School Chemistry, p. 18.

[5]National Survey of Secondary Education, Instruction in Science, Bulletin, 1932, No. 17, p. 11.

was brought out by this study of the objectives listed in the courses of study for the sciences. Of the 160 courses examined, only 11 courses stated the objective, "To acquire the knowledge necessary to correct superstition and erroneous beliefs." From this it can be inferred that this science objective is only a minor one, but most people will agree that it is a very important one.

In the thirty-first yearbook, Part 1, of the National Society for the Study of Education, 1932, in a volume entitled, A Program for Teaching Science,[6] the stand taken by a committee reporting on the objectives of science teaching shows that they recognize the aim of science teaching to be contributory to the aim of education, that is, life enrichment. They further recognize the objectives of science teaching to be the functional understanding of the major generalizations of science and the development of associated scientific attitudes. This is based on the opinion of the members of the committee reporting but represents the best composite thinking obtainable on this subject. One of the difficulties which arises and which must be eliminated before much progress can be made in formulating a truly scientific curriculum is that of discovering a method for determining and evaluating the objectives of science teaching.

[6] Ibid., p. 13.

The subject matter of a chemistry course should be so organized that the emphasis is not placed upon the accumulation of details and facts but rather upon understanding. Chemistry should not be simply the sum of the known facts about the chemicals with which a chemist deals, but it should be an understanding of the principles of chemistry through the mastery of which one secures a basis for the interpretation of the world in which he lives.

The units that have been developed in this study present chemistry from a practical point of view. They cover the basic principles of chemistry, but yet present the subject matter with the thought always in mind of the students' common everyday interests, experiences, and activities. The student will develop an understanding of science as it touches him in the home and community. He will also be able intelligently to enjoy the popular science articles found in our various publications, but more important than that will be his ability to know the chemistry related to his own health and to the health of his future children.

The units cover the chemistry subject matter in such a way that a student taking the course will be well prepared to continue chemistry in college. Those students that will not attend college will be better prepared as future parents and citizens of the nation than if they had taken the chemistry course heretofore taught as a college preparatory course. Chemistry taught along these lines will be a definite step towards putting this science in its proper place in the integrated curriculum.

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